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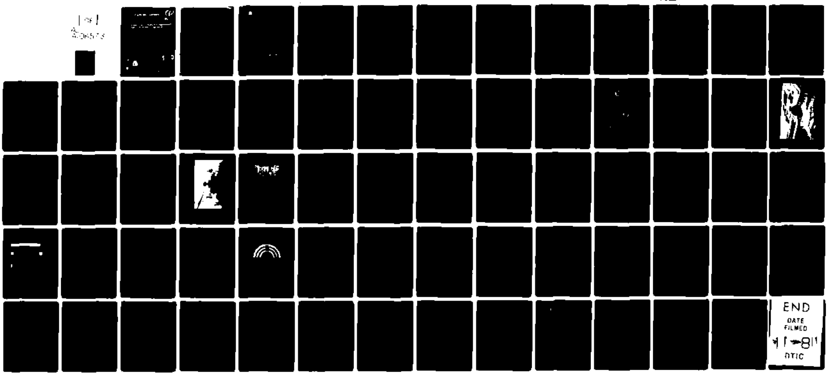

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REPORT BY THE

Comptroller General

OF THE UNITED STATES

LEVEL II

(6)

Is Spent Fuel Or Waste From Reprocessed Spent Fuel Simpler To Dispose Of?

Although there is general agreement that the U.S. should safely and permanently dispose of high-level nuclear waste, there is substantial disagreement about whether that should include spent fuel or just the unusable part of the spent fuel that remains after chemical reprocessing. Currently, the Department of Energy plans to permanently dispose of spent fuel without reprocessing, but some experts believe that this will waste a valuable source of uranium and plutonium and pose special waste isolation problems.

From the viewpoint of nuclear waste disposal alone, GAO believes it makes sense that spent fuel not be buried in a repository, but instead be reprocessed to recover the valuable uranium and plutonium. But an important--and unknown--factor in this decision is the future role of commercial nuclear power in the United States.

Until the Congress makes a decision on the future of nuclear power, DOE has no option but to plan for any eventuality--including the potential geological disposal of spent fuel. Other long-term storage options are available which would keep spent fuel above ground easily accessible for future use. DOE's consideration of these options would guarantee that the United States is able to handle any eventuality regarding the future need for nuclear power.

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UNITED STATES GENERAL ACCOUNTING OFFICE

(14) GAO/EMD-81-78
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ERRATA

To the recipients of the Comptroller General's Report to the Congress entitled "Is Spent Fuel or Waste from Reprocessed Spent Fuel Simpler to Dispose of?" (EMD-81-78, June 12, 1981):

Insert the following before the first line of page 44:

DOE, however, believes that we should have also considered the "waste isolation system's capacity to assure

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D.C. 20548

B-203293

The Honorable Marilyn Lloyd Bouquard
Chairman, Subcommittee on Energy
Research and Production
Committee on Science and Technology
House of Representatives

Dear Madam Chairman:

On May 5, 1980, the former Subcommittee Chairman requested that we review the Department of Energy's (DOE's) high-level nuclear waste program. This program is geared toward developing a geological repository by the year 2006 which will be capable of accepting both spent fuel from commercial reactors and waste from reprocessed spent fuel.

The report (1) concludes that spent fuel is more difficult to isolate from the biosphere than high-level waste reprocessed from spent fuel and (2) discusses the status of DOE's efforts to provide a manmade barrier system which, when placed around the waste in a repository, will contain the radioactivity for at least the first 1,000 years.

As discussed with your office, this report will be available for unrestricted distribution in 30 days unless you publicly announce its contents earlier.

Sincerely yours,

Acting Comptroller General
of the United States

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COMPTROLLER GENERAL'S REPORT TO THE SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY

IS SPENT FUEL OR WASTE FROM REPROCESSED SPENT FUEL SIMPLER TO DISPOSE OF?

D I G E S T

Since the early development of nuclear power, the Federal Government has known that eventually it would have to develop a safe, long-term method to store or permanently dispose of highly radioactive nuclear wastes. The lack of a permanent solution to the spent fuel and high-level wastes issue has been a fundamental problem hindering the growth of nuclear power.

Nuclear opponents have continually used this issue as an argument for discontinuing nuclear power. Indeed, everyone in the Government and nuclear industry recognizes that spent fuel and high-level wastes, which remain hazardous for an extremely long period of time, cannot continue to be accumulated without some means to insure their permanent isolation from the biosphere. Already there are about 100 million gallons of high-level wastes and 5,900 metric tons of spent fuel being temporarily stored around the country. These amounts are expected to increase to 107 million gallons and 63,000 metric tons, respectively, by 1995. (See pp. 1 to 3.)

Several methods for disposing of high-level wastes and/or spent fuel have already been considered, including disposal in geological repositories, the ocean floor, polar ice regions, and outer space.

Geological repositories were selected because they provide the best long-term certainty for isolation. During the 20 years since such repositories were first suggested, however, attempts to identify and develop disposal sites have been unsuccessful. In most cases, the attempts failed or problems surfaced primarily because of public and political opposition rather than for technical reasons.

The Department of Energy (DOE) has stepped up its effort to find an acceptable disposal method for both spent fuel and high-level nuclear waste. It has created a Nuclear Waste Management Program office and increased its waste isolation budget. More importantly,

DOE is attempting to resolve all significant unknowns and identify the best possible disposal technologies and repository sites. DOE believes that this approach is the only viable way to convince State and local political leaders, as well as the public, of the acceptability of its waste management program. (See p. 4.)

DOE is studying several types of geological media (i.e., salt, basalt, granite, and tuffs) to determine which is best suited for a repository. In addition, it is looking throughout the United States for the most acceptable rock formations in terms of geological stability and isolation from ground water.

DOE is also designing a series of barriers which will surround the nuclear wastes once they are placed in the repository. These barriers will help to prevent the migration of radioactivity from the repository. They will be made of special materials capable of withstanding corrosion and/or absorbing radionuclides that might leach from the nuclear wastes. DOE's goal is to guarantee that these barriers, known as the "waste package," will completely contain either spent fuel or high-level wastes for at least the first 1,000 years in the repository. (See p. 5.)

DOE estimates the first repository will not be completed for 20 years. The program to get a repository open is really the first comprehensive effort made by the Federal Government which addresses all the technical, political, and social issues involved, including the concerns of States and individual localities where the repositories might be located. (See p. 6.)

SPENT FUEL--A CONTROVERSIAL ISSUE

While everyone agrees that this country should safely and permanently dispose of high-level nuclear waste, there is substantial disagreement about whether that

should include spent fuel or just the unusable part of the spent fuel that remains after chemical reprocessing. The most recently proposed solution by the previous administration was to permanently dispose of spent fuel without reprocessing. This could restrict the availability of plutonium (which is separated from spent fuel during reprocessing) and thus limit the spread of nuclear weapons. However, representatives of the nuclear industry as well as others believe this solution is short-sighted and wasteful, because the unused uranium and plutonium in spent fuel represent the energy equivalent of billions of barrels of oil. (See p. 6.)

In developing the nuclear waste management program, the previous administration assumed that spent fuel could be as easily stored or isolated from the environment as reprocessed high-level waste. GAO does not agree with that assumption. GAO found that the form of the waste--spent fuel or solidified high-level waste--will have a significant influence not only on the location, design, and possibly the number of repositories, but also on the ability of DOE to assure isolation of waste for the period of its toxicity. (See pp. 25 to 31.)

Based on information obtained to date, DOE contractors believe a waste package can be designed to contain either spent fuel or high-level waste for 1,000 years. Because of the extended toxic life of spent fuel, however, the geology must serve as the primary barrier between it and the environment. The waste package offers little long-term advantage in this case. High-level waste, on the other hand, decays before 1,000 years to a radioactive level less than that of naturally occurring uranium ore. Thus, the waste package offers major advantages in the disposal of high-level wastes. (See p. 32.)

CONCLUSIONS

As presently constituted, DOE's technical waste program is making progress. DOE believes, and GAO tends to agree, that the major obstacle to geological disposal is not the technology, but

public and political acceptance of the waste disposal concept and of the localities where the respositories will be located. One of DOE's program objectives is to research potential problems and resolve public fears associated with nuclear waste disposal. DOE believes this will provide, under current schedules, the first geological repository sometime between 1997 and 2006.

One of the major controversies associated with DOE's waste management program is the handling of spent fuel. At present, DOE is planning to bury it as a nuclear waste. Some experts and political leaders believe that spent fuel may be too valuable a resource to throw away and that its disposal creates special waste isolation problems. (See p. 39.)

GAO found that spent fuel does indeed create problems that make its isolation more difficult. For instance, spent fuel contains mostly long-lived radionuclides, such as plutonium and uranium, which remain toxic for hundreds of thousands of years.

High-level waste, on the other hand, has most of these long-lived elements removed during reprocessing, and it decays to radioactive levels of naturally occurring uranium ore in about 600 to 1,000 years. DOE believes it has the technology to fabricate a barrier system which will isolate the wastes for 1,000 years, thus removing the potential hazards of the high-level waste but not those of spent fuel. (See pp. 39 and 40.)

In addition, GAO found that spent fuel

--unlike high-level waste, cannot be made into a homogeneous mixture to suit the characteristics of the repository and other parts of the waste system, which makes it more difficult to prove the long-term integrity of the repository;

--could require three times as much area in a repository as reprocessed high-level waste;

--will cost more to dispose of than high-level waste, considering the value of the uranium and plutonium recovered during reprocessing;

--is a valuable energy resource, particularly if other advanced energy technologies under development do not progress as expected; and

--even when disposed of does not eliminate the proliferation problem but merely transfers it to future generations who might find it necessary to exhume the spent fuel for whatever purposes they consider necessary, including the manufacture of nuclear weapons.

Thus, when considering only the impact on nuclear waste disposal, it makes sense that spent fuel not be buried in a repository but instead be reprocessed to recover the valuable uranium and plutonium. Unfortunately, the solution to the reprocessing question cannot be based solely on the waste disposal issue. A much more overriding consideration is the future role that commercial nuclear power will play in this country. (See p. 40.)

If nuclear power is intended only to serve as a stop-gap energy alternative until other advanced technologies are developed, there is no question that spent fuel will not be needed and must eventually be buried or otherwise isolated from the accessible environment. But if commercial nuclear power makes a strong comeback and fulfills the predictions from its early development, spent fuel will be a valuable resource, worth the equivalent of billions of barrels of oil.

Unfortunately, however, the United States as a country has been ambivalent toward the future of commerical nuclear power. On the one hand, the country recognizes that nuclear power has the potential (through development of the breeder reactor and other advanced nuclear technologies) to provide all of our electricity needs for centuries, while on the other hand there are still concerns about the many potential or perceived safety and environmental hazards of nuclear power. (See p. 41.)

Therefore, until the Congress makes a decision on the future of nuclear power, DOE has no option but to plan for any eventuality--including the potential geological disposal of spent fuel. To do anything less would be a failure to carry out its waste isolation responsibilities. Other long-term storage options are available, however, which would keep spent fuel above ground and easily accessible for future use. DOE's consideration of these options would guarantee that the United States is able to handle any eventuality regarding the future need for nuclear power. (See p. 41.)

AGENCY COMMENTS

DOE agrees with GAO's overall conclusions that spent fuel is not necessarily the optimum waste form when compared to other forms under development. However, DOE believes GAO arrived at its conclusions using elementary analysis and noted that certain positions needed clarification. GAO disagrees that its analysis is elementary and believes the report fully compares the potential impact on man from disposing of both types of waste. GAO's evaluation of DOE's written comments is included in appendix I. The full text of those comments is presented in appendix II.

Contents

ABBREVIATIONS

DOE	Department of Energy
NRC	Nuclear Regulatory Commission
GAO	General Accounting Office
ONWI	Office of Nuclear Waste Isolation

CHAPTER 1

INTRODUCTION

High-level nuclear wastes have been accumulating in this country for almost 35 years--primarily the result of nuclear weapons production. Already about 100 million gallons are being stored in underground tanks at several federally owned locations and at one state-owned site in West Valley, New York. In addition, about 5,900 metric tons of used or "spent" nuclear fuel have been removed from commercial powerplants and are being temporarily stored in water pools at the plant sites or other central locations. Spent fuel, which is expected to accumulate to 63,000 metric tons by 1995, contains all the long-lived, toxic elements found in high-level wastes and presents many of the same health, safety, management, and isolation problems. 1/

In any event, both high-level nuclear wastes and spent fuel are accumulating and could threaten the public health and safety for thousands of years if not properly handled and isolated from the environment. Thus, one of the highest priority programs of the Federal Government at this time is to devise a waste disposal scheme that will guarantee the permanent isolation of both types of materials.

DESCRIPTION OF SPENT FUEL AND HIGH-LEVEL WASTE

Spent fuel, simply stated, is the used uranium fuel that has been removed from a nuclear reactor. Contrary to its name, however, spent fuel is not completely "spent." It still contains significant amounts of re-usable uranium (about 95 percent in commercial spent fuel) and small amounts of plutonium which were created during the nuclear fission process. The remainder includes mostly "fission products"--such as strontium and cesium--that were also created during the fission process but which have little or no residual value.

High-level waste, on the other hand, is a term which describes the waste by-products coming out of a spent-fuel reprocessing plant. For instance, the Department of Energy (DOE) has several special nuclear reactors whose purpose is to create plutonium for making nuclear weapons. This is done through the chain reaction that occurs in the core of the

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1/We understand that NRC considers spent fuel to be high-level nuclear waste for the purposes of licensing storage facilities under section 202(3) of the Energy Reorganization Act of 1974. (42 U.S.C. 5842(3).)

reactor. Before the plutonium can be used, the spent fuel must be removed from the reactors and sent to one of three Federal reprocessing plants. Here the fuel is dissolved and (through a series of complicated processes) separated into streams of uranium, plutonium, and "high-level" waste.

The uranium and plutonium are subsequently solidified and converted into either fresh reactor fuel or material for nuclear weapons. The high-level wastes remain in liquid form and are transferred to underground storage tanks close to the Federal reprocessing installations. Besides the strontium, cesium, and other highly toxic fission products, high-level waste includes chemical solvents and other materials used to dissolve or process the spent fuel.

WHY ARE SOLUTIONS TO THE NUCLEAR WASTE PROBLEM NEEDED?

Over the past few years, nuclear power has been an extremely controversial subject. Opponents have become more and more vocal, questioning the huge costs and safety of various nuclear technologies, the potential proliferation of nuclear weapons that may be inherent in an economy based on nuclear power, and the lack of a proven technology to deal with spent fuel and insure that high-level wastes are permanently isolated from the environment. These, along with inconsistent Federal policies and regulatory requirements, have helped to severely curtail, if not eliminate, the growth of nuclear power.

Of these issues, the one that has done as much as any, if not more, to hinder the growth of nuclear power is the lack of a permanent solution to the spent fuel and high-level waste problem. Interveners and public interest groups have continually used this issue as an argument for discontinuing nuclear power. Indeed, everyone in the Government and nuclear industry recognizes that spent fuel and high-level wastes cannot continue to be accumulated without some means to insure their permanent isolation from the environment.

Already, some defense high-level wastes have been stored for 35 years, approaching and sometimes exceeding the life expectancy of their storage tanks. More importantly, some tanks have cracked and leaked significant amounts of radioactive materials into the ground. Although DOE has apparently resolved these problems, the fact remains that high-level liquid wastes are extremely hazardous and will remain so for thousands of years. They must be monitored until they are safely removed from the tanks, solidified, and permanently placed in disposal facilities.

The issues associated with commercial spent fuel are somewhat similar but more complicated. Not only is spent fuel hazardous but it is also accumulating without any definite Federal policy for resolving its future. For instance, the Federal Government and nuclear industry always expected that commercial spent fuel would be routinely shipped offsite to commercial reprocessing facilities. Here (as at defense reprocessing plants) the unused uranium and plutonium would be recovered and the high-level waste products would be separated for eventual solidification and disposal.

For several reasons, however, commercial reprocessing ventures in the United States never developed as expected. This meant that utilities, with no place to ship their spent fuel, had to expand existing powerplant storage pools and undertake a perpetual spent-fuel storage program they had neither anticipated nor wanted. Still they hoped that commercial reprocessing would eventually be developed and that the backlog of spent fuel would begin to decline. In fact, the largest reprocessing plant in the world was being built at Barnwell, South Carolina, and was expected to begin operating in the latter part of the 1970s.

In 1977, however, the administration proposed that commercial reprocessing be "indefinitely deferred" in this country, ending any hope that Barnwell or any other commercial reprocessing plant would provide immediate relief for the spent-fuel storage problem. This deferral occurred because of a deep concern that spent-fuel reprocessing could lead to the worldwide proliferation of nuclear weapons. At that time, India had recently exploded a nuclear bomb (possibly by reprocessing plutonium from commercial grade spent fuel) and some industrial nations were considering the sale of reprocessing plants to other, less developed countries. Thus, the threat of nuclear weapons was viewed as a greater problem than the need for continued development of commercial nuclear technology. Consequently, policies and programs were geared toward phasing out commercial spent-fuel reprocessing, not only in this country but worldwide.

Under this scheme, it was recognized that spent fuel could not be indefinitely stored at powerplant sites. Therefore, if the decision to defer reprocessing was to succeed, a viable method to handle spent fuel was needed. As a result, it was proposed that the Federal Government assume ownership of U.S. and some limited amounts of foreign spent fuel and be responsible for their final disposition. Additionally, it was suggested that the residual value of the uranium and plutonium be forgotten and that spent fuel be reclassified as a

nuclear waste. This would mean adjusting Federal waste management programs to accommodate the potential disposal of spent fuel and trying to convince foreign governments to do the same.

FEDERAL ACTIONS TO DISPOSE OF HIGH-LEVEL WASTE AND SPENT FUEL

Since the early development of nuclear power, the Federal Government has known that it would have to eventually develop a safe, long-term method to store or permanently dispose of highly radioactive nuclear wastes. In fact, several methods were considered, including disposal in geological repositories, the ocean floor, polar ice regions, and outer space. Ultimately, geological repositories were selected because they provide the best long-term certainty for isolation considering the state of our technological development. During the 20 years since geological repositories were first suggested, however, attempts to identify and develop disposal sites have been unsuccessful. In almost all cases, the attempts failed or problems surfaced primarily because of public and political opposition, rather than for technical reasons. 1/

In response to the redirected nuclear policy, DOE, subject to the licensing authority of the Nuclear Regulatory Commission (NRC), 2/ embarked on a revitalized program to find an acceptable method for disposing of both spent fuel and high-level nuclear waste. For instance, DOE has created a special Nuclear Waste Management Program office and increased its waste isolation budget. More importantly, DOE is attempting to successfully resolve all significant unknowns and identify the best possible repository sites. DOE believes that this is the only way to convince State and local political leaders, as well as the public, of the acceptability of its waste management program.

1/For a description of these efforts, see our report entitled, "The Nation's Nuclear Waste--Proposals for Organization and Siting," EMD-79-77, June 21, 1979.

2/The Nuclear Regulatory Commission, under the Energy Reorganization Act of 1974, is required to license any facility built to dispose permanently of high-level nuclear waste. As part of its responsibility, NRC is presently developing both technical and procedural criteria which must be met by DOE before a repository can be licensed and built.

Among its activities, DOE is studying several types of geological media (i.e., salt, basalt, granite, and tuffs), attempting to determine which is best suited for a repository. In addition, it is canvassing the United States, looking for the most acceptable rock formations in terms of their geological stability and isolation from circulating ground water. Water is particularly important because it is the primary way that nuclear wastes could escape from a repository.

In a concurrent effort, DOE is designing, pursuant to an NRC requirement, a series of man-made barriers which will surround the nuclear wastes (once placed in the repository) to provide greater assurances that they will not migrate from the repository. These barriers will be made of special materials capable of withstanding corrosion and/or absorbing radionuclides that might leach from the nuclear wastes. DOE's goal is to guarantee that these barriers will contain either spent fuel or high-level wastes for at least the first 1,000 years in the repository.

In this respect, one of DOE's major efforts over the past years has been to develop a way to solidify and permanently immobilize the millions of gallons of high-level liquid waste currently in temporary storage. Based on results to date, DOE (as well as most other countries with high-level waste disposal programs) have determined that borosilicate glass is the best material to immobilze the waste. The process involves mixing the solidified (powdered) waste with hot melted glass, then pouring it into a container, and letting it cool into a solid form. The resulting glass solid has an acceptable leach rate, and is not affected by the heat or radiation expected from the waste.

The first geological repository under DOE's waste management program is not expected to be completed until sometime between 1997 and 2006. DOE believes this is a realistic schedule considering it must adhere to waste management guidelines provided by President Carter in February 1980. The guidelines, which were consistent with those developed by the Interagency Review Group on Nuclear Waste Management, 1/ require DOE to

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1/A group created by President Carter on March 13, 1978, consisting of representatives of 15 Federal agencies and charged with the responsibility for recommending a nuclear waste policy and programs to implement it.

--develop concurrent information on a number of potential repository locations and geological media, before deciding where the first repository will be located;

--design geological repositories capable of isolating both spent fuel and high-level wastes;

--provide for the retrievability of the nuclear wastes (within the first 50 years) if that proves necessary for health and safety reasons; and

--give State and local governments an effective role in implementing the nuclear waste management program.

Even though the first repository will not be completed for 20 years, this is the first comprehensive effort made by the Federal Government to address all the waste management issues, including those associated with the political and social concerns of the States and localities where the repositories might be located.

INDUSTRIAL AND POLITICAL RESPONSE TO THE ADMINISTRATION'S MANAGEMENT PROGRAM

As with any controversial subject, the response to the previous administration's waste management efforts has been mixed. The nuclear industry, for instance, has welcomed the increased Federal emphasis and priority given to the nuclear waste disposal issue but does not support attempts to dispose of spent fuel as a nuclear waste. In effect, the industry views this decision as an indictment of commercial nuclear power, limiting its future to the extent of available uranium resources. This would mean the gradual phaseout of nuclear power sometime in the early 21st century. Additionally, some members of Congress and the public have questioned the wisdom of permanently disposing of spent fuel. They view spent fuel as a potentially valuable resource that might be needed if other emerging energy technologies do not develop as expected.

Equally as important, some members of these groups believe that spent-fuel disposal creates special problems that might hinder the development of an acceptable waste repository program. This is due partially to the difficulty in guaranteeing that spent fuel can be kept isolated for the thousands of years it remains hazardous.

Because of these types of controversies, the Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology, requested that we review the issues

relating to spent-fuel disposal and the likelihood that DOE can design and build a containment system capable of isolating both spent fuel and high-level wastes for the period of their potential hazard.

OBJECTIVES, SCOPE, AND METHODOLOGY

The Chairman, Subcommittee on Energy Research and Production, House Committee on Science and Technology asked two specific questions concerning the nuclear waste disposal program.

--Is spent fuel simpler to dispose of than waste from reprocessed spent fuel?

--Will the use of modern material in manmade barriers contain the wastes (both spent fuel and high-level) until they decay to the level of naturally occurring uranium?

The objectives of the review, therefore, were to:

--identify the problems, if any, associated with disposing of the two different wastes and determine if one has distinct disposal advantages over the other, and

--determine the status of DOE's program to develop manmade barriers to surround the wastes (once in the repository) and reduce the likelihood they will escape to the accessible environment.

To satisfy the first objective we assumed that spent fuel and solidified high-level wastes had arrived at a repository location, ready for disposal. At that point, we evaluated (1) the relative toxicity and length of time each material remains hazardous, (2) the likelihood that DOE can guarantee isolation of both types of wastes for the periods of their toxicity, (3) the costs of disposing of each type of waste in terms of repository spacing requirements and the number of repositories required, (4) the nuclear weapons proliferation issue related to disposal of spent fuel, and (5) other related technical and political issues associated with handling, evaluating, and disposing of one type of waste over the other.

To keep our review focused on the Committee's questions, we excluded a number of related issues from our analysis. These issues did not have a direct bearing on the design, construction, operation, or cost of a waste repository but

would have to be evaluated before deciding whether or not to reprocess spent fuel. Included in these issues are the relative costs and/or hazards associated with (1) transporting spent fuel versus high-level wastes, (2) reprocessing spent fuel and solidifying the high-level wastes, and (3) safeguarding or protecting plutonium from diversions by either terrorist organizations or countries wishing to develop nuclear weapons. In addition, the need for reprocessing largely depends on the availability of uranium resources to fuel future nuclear reactors and the potential that other advanced energy technologies will be developed in time to take the place of nuclear power as a major energy resource. These issues were also excluded from our analysis.

For the second objective, we assessed DOE's program to design a waste package or multi-barrier system for containing waste within a geological repository. The assessment was performed by reviewing research results pertaining to each individual barrier in the system and discussing the results with DOE officials and the research contractors. We compared the information obtained from DOE and its contractors with NRC's proposed requirements for the barrier system and formulated our conclusions. We accepted the research results and conclusions as valid.

To obtain the necessary information, we interviewed officials at DOE and NRC headquarters offices in Washington, D.C., and at DOE field offices involved in the waste management program at Albuquerque, New Mexico; Columbus, Ohio; Las Vegas, Nevada; Richland, Washington; and Savannah River, South Carolina. We also interviewed DOE contractors at these locations who were actually performing the research and development work. These contractors were

--Sandia National Laboratory in Albuquerque,

--Battelle Memorial Institute in Columbus,

--E.I. DuPont and NeMours in South Carolina,

--Rockwell International Corporation in Richland, and

--Sandia National Laboratory, Los Alamos National Laboratory, Lawrence Livermore Laboratory, and the U.S. Geological Survey, all at the Nevada Test Site.

In addition, we relied heavily on technical documents published by DOE and its contractors.

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The next chapter reports the status of DOE's nuclear waste disposal program, describing in greater detail the geological repository concept and ongoing work. Chapters 3 and 4 address the specific questions asked by the requestor, and chapter 5 gives our conclusions and observations.

CHAPTER 2

NUCLEAR WASTE DISPOSAL PROGRAM--A STATUS

DOE has a major program underway to dispose permanently of highly radioactive and very toxic nuclear wastes. This program, which is estimated to cost $1.86 billion over the next 5 years, is geared toward developing an underground repository by at least the year 2006 which can accommodate not only spent nuclear fuel from commercial reactors, but also high-level nuclear wastes generated by reprocessing spent fuel.

This effort is clearly one of the highest priority programs at DOE--so important that the near-term future of commercial nuclear power may rest on DOE's ability to meet its schedules and commitments. More importantly, many millions of gallons of highly toxic liquid defense wastes are already being temporarily stored at several DOE national laboratories--the product of years of nuclear weapons production. A solution must be found for the permanent isolation of these materials regardless of the future direction that commercial nuclear power takes in this country.

Under DOE's overall direction, the Battelle Memorial Institute in Columbus, Ohio, is managing the major portion of the waste disposal program. Battelle's special project office, called the Office of Nuclear Waste Isolation (ONWI), is responsible for identifying potential repository sites in several different types of geological media, designing a repository for each type, and developing a waste package system capable of containing the waste for at least 1,000 years after it is placed in a repository. In addition, ONWI is responsible for coordinating all waste isolation activities at DOE to insure that all pieces of the program fit together and that duplication is avoided.

The total ONWI budget for fiscal years 1979, 1980 and 1981, which is $266 million out of a total DOE waste management budget of $531 million for the same 3 years, exemplifies ONWI's major involvement.

ONWI'S PROGRAM OBJECTIVES, IMPLEMENTATION, AND STATUS

To carry out DOE's program, ONWI has segmented its efforts into three major program areas. These include (1) identifying a suitable site for a geological repository, (2) developing repository designs for different types of

rock, and (3) designing a series of manmade barriers--called a waste package--to provide additional isolation protection for the waste.

The ultimate objective is to have an operational repository between 1997 and 2006 which is capable of accepting both commercial spent fuel and defense high-level waste. DOE estimates that such a repository with its multiple barrier system will cost between $2.17 billion to $3.95 billion, depending upon the rock type in which the repository is to be built and the repository size.

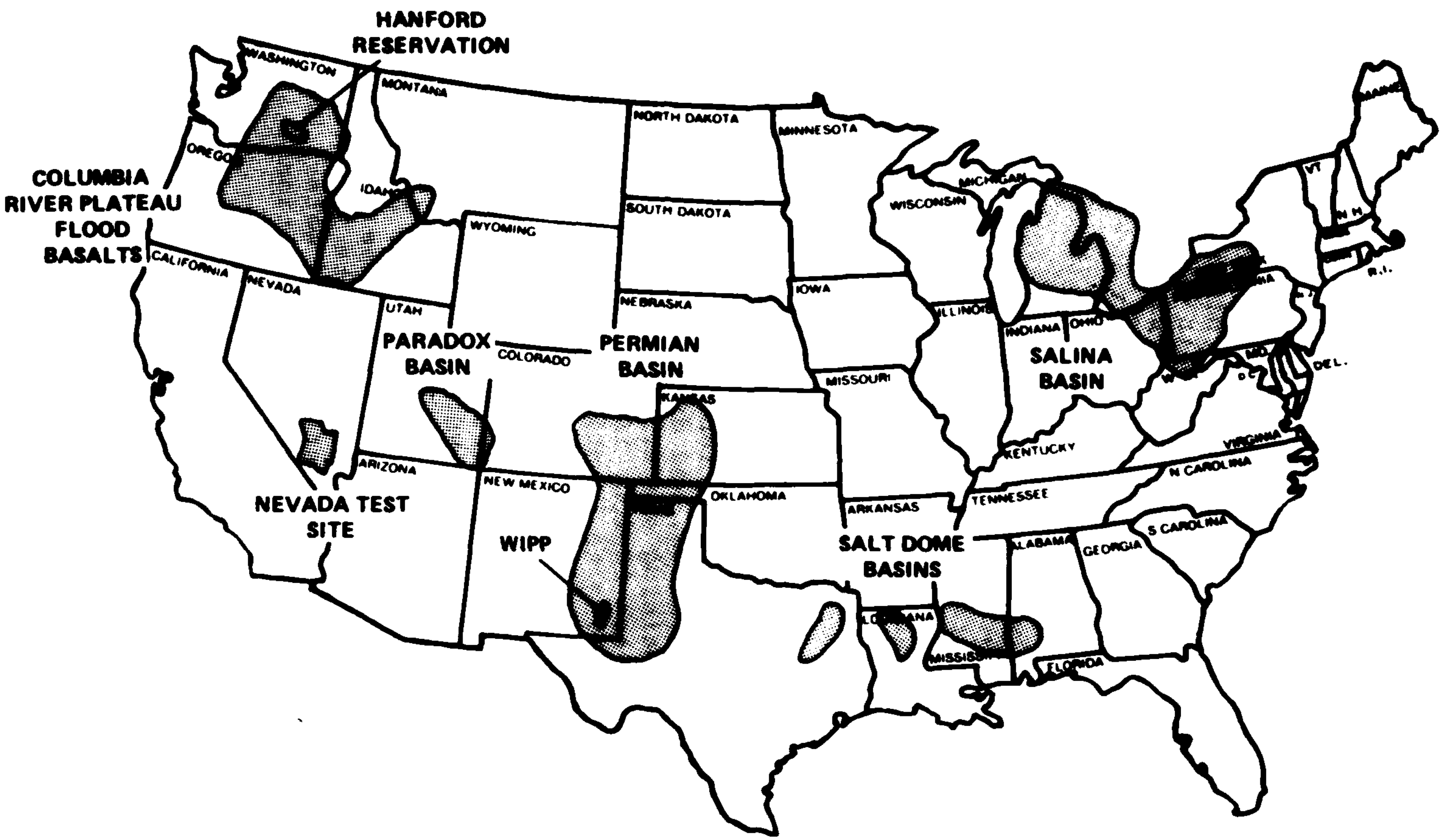
Repository siting--a critical program element

ONWI is currently screening the United States, trying to identify several acceptable repository sites by 1985. While this effort is progressing in some regions, State and local jurisdictions in other regions are hampering the site-screening process. This may eventually require the Federal Government to act unilaterally without State concurrence.

ONWI's process for identifying potential sites has included the study of successively smaller land units. At first, regions within the United States were selected by using existing literature in scientific reports, geological maps, earthquake occurrence, and drilling records. (See next page.) The remaining steps, which have progressed to varying degrees in each region, involve some core sampling and exploratory drilling to identify areas (about 1,000 sq. miles), locations (about 30 sq. miles), and finally potential repository sites.

The three most important factors in this screening process are the rock type, the hydrology (water), and the past and future land uses. The rock type that has historically held the most promise and which has been studied the most extensively is salt. As far back as the 1950s, salt was identified as the leading candidate in which to build a repository. It is almost devoid of water, has existed for millions of years in stable formations, and is plentiful.

To date eight potential locations have been identified in either salt domes or bedded salt. In fact, some experts contend that using today's technology, a repository could be built rather quickly in one or more of the existing salt locations (assuming State concurrence and that the remaining



REGIONS BEING INVESTIGATED FOR TERMINAL STORAGE
OF RADIOACTIVE WASTES

site investigative work proved positive). Under the existing program, however, the work in salt will continue until acceptable repository sites are determined. These sites will then be "banked" or put into reserve until concurrent site selections are made in other geological mediums, such as basalt, tuffs, and granite. All the potential sites will then be studied and compared, with the first repository site selection scheduled for 1987. Hopefully this site will be the best for housing a repository, both technically and politically.

Under this approach, the tentative site selection dates for each of the rock types are as follows:

Rock Type	Tentative Site Selection Date
Basalt	February 1983
Salt Dome	July 1983
Bedded Salt	September 1984
Tuffs	November 1984
Granite	June 1985

The site screening process is currently the most expensive program element at ONWI, costing $62 million in 1979 and 1980, and an estimated $30 million in 1981. DOE estimates site screening, including work at the Hanford and Nevada projects, will cost $551 million through 1987--the date DOE expects to select the first repository site.

The major problem associated with site selection is obtaining public and political acceptance. For instance, DOE (through ONWI) has been successfully prohibited from screening some areas of the country because of State and local opposition. Some States have refused to permit a repository within their borders. Others have been suspicious of DOE's motives and fear that if screening efforts are permitted, DOE will select their State as a repository location without adequate public participation or State concurrence.

DOE has met extensively with State and local officials as well as with public and civic groups, attempting to explain the overall waste isolation program and offer assurances that the State and public will have a voice in site selection. This is a type of process which we favored

in a previous report issued in June 1979. 1/ In that report we concluded that, no matter how successful the technical aspects of DOE's waste isolation program, a repository will not likely be built until the political aspects and public fears are adequately addressed and resolved.

We further concluded that if all State concurrence efforts fail, the Federal Government may have to act unilaterally to override State and local opposition and select the best repository site available. The waste problem is already of such paramount importance that a solution must be obtained, even if one or more segments of the public are dissatisfied.

Repository and waste package design

The other major activities of ONWI include (1) developing repository designs for different types of rock and (2) designing waste packages to provide additional isolation protection for the wastes. (See next page.)

Repository design

The repository design work at ONWI includes the surface waste processing facilities, the shafts down to the storage rooms, the underground rooms and tunnels, and all the necessary handling equipment. Essentially everything manmade except the waste package is included. In addition, ONWI is studying special construction techniques necessary for building a repository deep underground and also assessing the effects that heat (from the wastes) will have on the geological stability of the rock. Two conceptual designs have already been completed for a salt repository, and according to ONWI officials these can be modified and adapted to other geologies.

The repository design work at ONWI totalled about $32 million in fiscal years 1979 and 1980. The estimate for fiscal year 1981 is $16.2 million.

Waste package design

The objective of ONWI's waste package program (which is discussed in greater detail in ch. 4) is to design,

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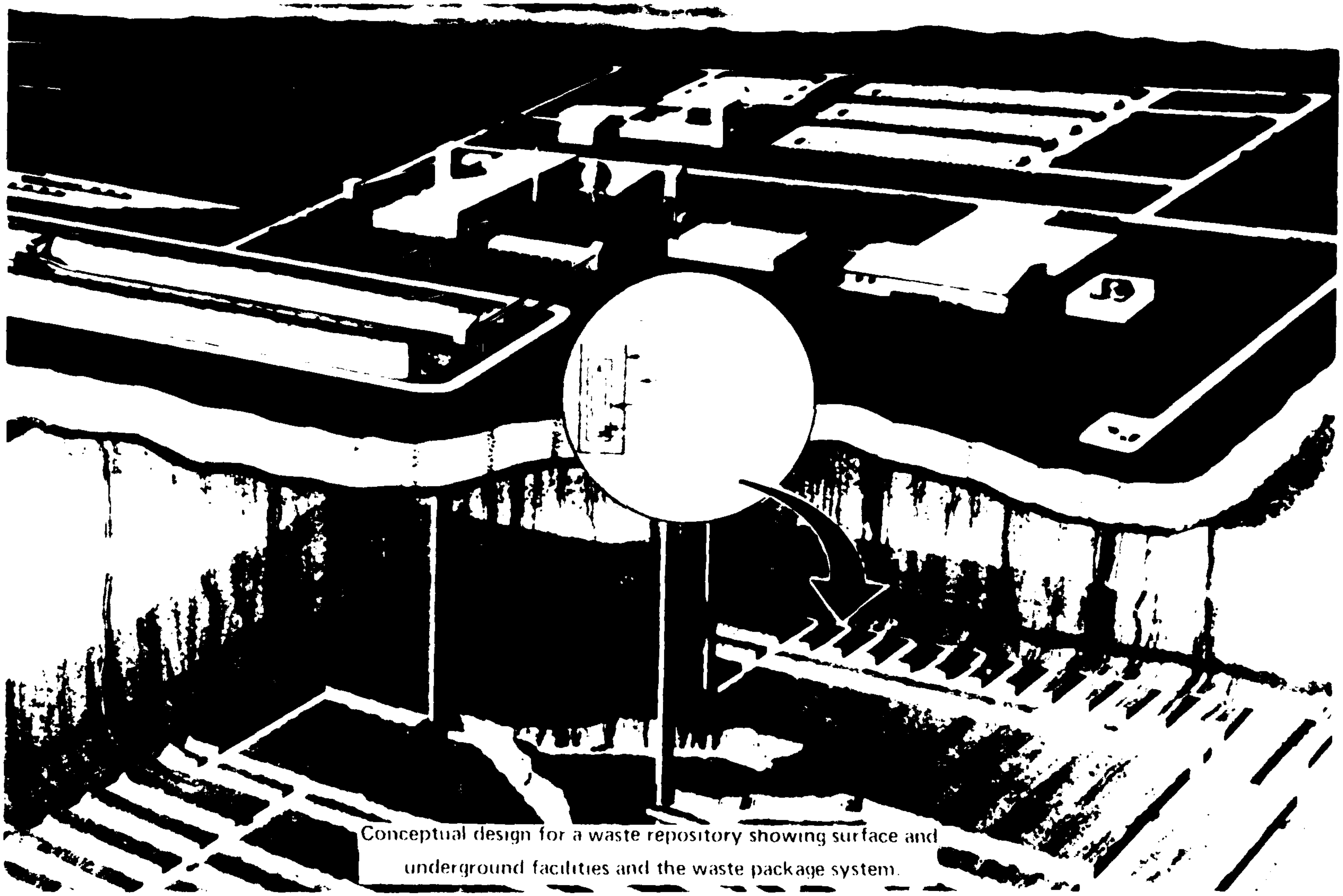
1/"The Nation's Nuclear Waste--Proposals for Organization and Siting," EMD-79-77, June 21, 1979.



Conceptual design for a waste repository showing surface and underground facilities and the waste package system.

develop, test, and receive licensing approval for waste packages that are usable in several different geologies. The primary emphasis of the program is to determine which package materials are the best for keeping water from reaching the waste and preventing radionuclides from escaping to the host rock. Sandia Laboratory in New Mexico is performing most of the research on the corrosion resistance of metals and on materials which will absorb and hold radionuclides for long periods.

ONWI's research and development costs for the waste package program during fiscal years 1979 and 1980 totalled $16 million. The estimated budget for fiscal year 1981 is $14 million. Final waste package designs are expected to be completed when the first site is selected in 1987.

SITE INVESTIGATIONS AT DOE RESERVATIONS

In addition to the site screening work being done by ONWI, DOE is investigating the geology at two of its national laboratories as potential repository locations. These laboratories--the Hanford Reservation near Richland, Washington, and the Nevada Test Site near Las Vegas, Nevada--are both committed to Federal nuclear activities and are already partially contaminated with radioactivity. During fiscal years 1979, 1980 and 1981, DOE had budgeted $114 million and $64 million to Hanford and the Nevada projects, respectively. These projects are being managed by their respective DOE Operations Offices, although each coordinates extensively with ONWI to prevent overlap and insure consistent program objectives.

Basalt being studied at Hanford

The 576-square mile Hanford Reservation was selected for extensive study because it is underlain by thick basalt formations (a potentially acceptable repository rock) and is already committed to Federal nuclear activities. This latter point might make it easier to obtain public acceptance, as opposed to selecting new, uncontaminated lands as repository locations.

Although DOE conducted site investigative work at Hanford between 1968 and 1972, the current level of geologic and hydrologic study has been going on since 1977. During this time a test facility has been built to study the thermal, mechanical, and radiation effects of nuclear waste on basalt and to provide the engineering data needed to justify the future design and construction of a repository. To date,

test results indicate that basalt is an acceptable medium and that Hanford has suitable geological characteristics for housing a repository.

The biggest uncertainty about Hanford is the amount of ground water in or near the basalt, the ability of the ground water to interact with the radioactive waste, and the speed with which the ground water flows toward the nearby Columbia River. Although tests are still being conducted, DOE does not believe that the ground water flow will prevent constructing a repository.

In addition, concern has been expressed by DOE's Lawrence Berkeley Laboratory that the Hanford basalt formation might not be thick enough to house a repository. In a review it made of several DOE studies, Lawrence Berkeley found only one formation that is over 200 feet thick--the thickness the DOE contractor believes is needed for housing a repository. The review indicated that the thickness of this one formation varied so drastically over a distance of several miles, that its acceptability as a repository site is not certain.

<u>The Nevada Test Site as a potential repository</u>

The Nevada Test Site, which covers about 1,400 square miles, is being heavily studied as a potential repository location. Like Hanford it is already committed to Federal nuclear activities and might be a little easier for the public to accept. More importantly, the Test Site includes a variety of geological media--such as shale, granite, argillite (a compact clay rock), and tuff (a heat-fused volcanic ash)--all of which might be a good repository media. Unfortunately, any waste isolation activities cannot interfere with the prime mission of the Test Site--to test nuclear weapons. Thus, the exploration for a suitable repository is currently limited to the 300-square-mile southeast portion of the Site.

Besides attempts to locate a suitable repository location, efforts are underway at the Test Site to study the various geologies present and the impact that the weapons tests might have on repository designs and integrity. Of particular interest are two types of geologic rock--granite and tuffs. Evaluation of their suitability as repository rock is being conducted in two underground locations called "Climax" and "G-Tunnel."

The Climax project, which started in April 1980, is studying the feasibility of storing spent fuel in granite. The test consists of 11 spent-fuel canisters placed in granite 1,400 feet below the surface. This will help determine if radiation reduces the ability of the rock to contain high-level wastes. Electric heaters are also being used to determine how granite responds to the heat that may be present in an actual high-level waste repository. The following pictures show the Climax underground facility, including some of the spent-fuel storage holes, and a spent-fuel canister positioned in one of the storage holes.

The Climax facility, however, is within the nuclear weapons testing area and cannot be used as a repository. Additionally, there are no granite formations anywhere on the Test Site suitable for housing a repository. Nevertheless, DOE believes these test results will be applicable to granite formations in other parts of the country.

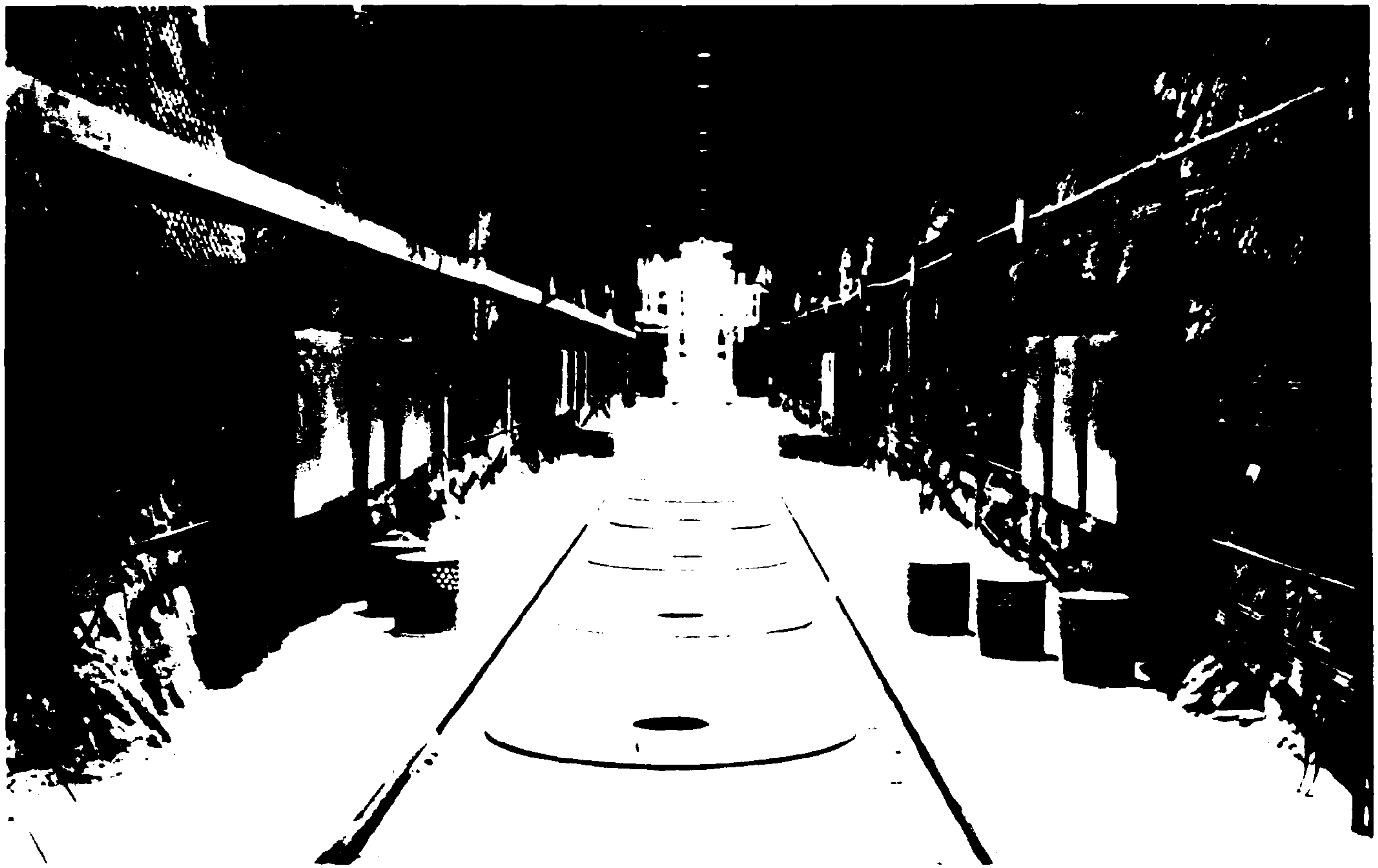
The G-Tunnel project is being conducted in a rock called "tuff." This was selected for study because it is very dense, will not allow a fast flow of water, can handle large heat loads, and will attract and hold radioactive elements from water that might come in contact with the nuclear wastes.

An underground electric heater experiment was begun in January 1980 at the tuffs site to provide data on water behavior and migration under the influence of a heat field. More extensive experiments in this geology are being planned at a potential repository location in the Test Site's Yucca Mountains.

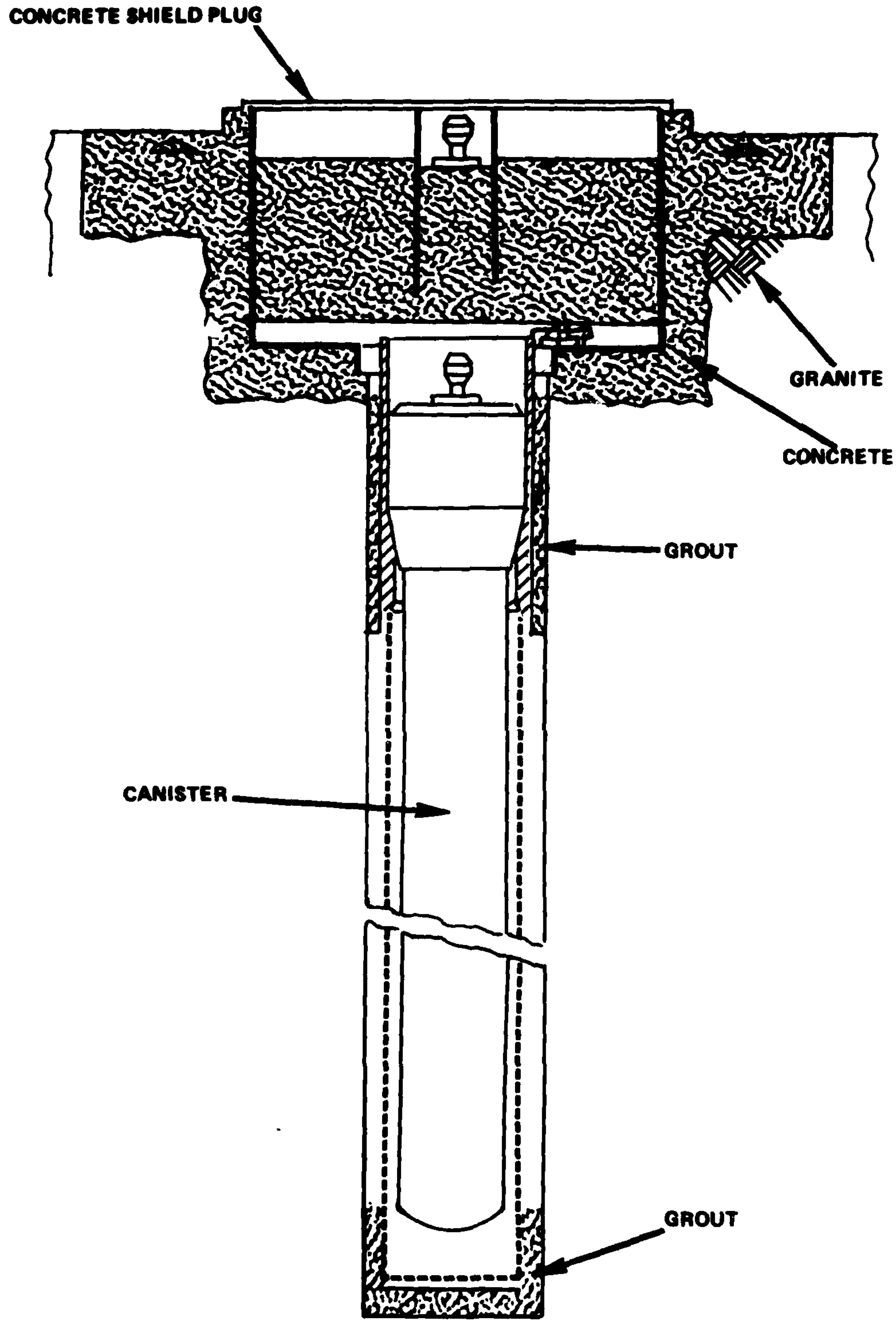
CONCLUSIONS

DOE's nuclear waste program is currently proceeding on a slow but orderly path, attempting to resolve not only the pending technical questions but also the political and social concerns surrounding the disposal of highly radioactive wastes. This is expected to result in the first geological repository sometime between 1997 and 2006, at an estimated cost of $2 to $4 billion.

While the program is deliberate and very comprehensive in terms of data being developed, we believe that this approach is necessary if a geological repository is ever to be built. The issues surrounding nuclear power in general, and waste disposal in particular, are so volatile and emotional that attempts to speed up the process may only result in additional failures. It is important, therefore, that all phases of the waste disposal program be well thought



SUBTERRANEAN SPENT FUEL TEST FACILITY, SHOWING ROW OF SHIELD PLUGS COVERING THE SPENT FUEL, CYLINDRICAL HEATERS APPEAR ON EACH SIDE.



METHOD USED TO EMPLACE SPENT FUEL IN GRANITE AT THE NEVADA TEST SITE.

out, researched, and based on the best technical information available. In addition, the remaining technical uncertainties should be understood by the State and local governments and the public before the first repository is built, to assure that all parties are aware of the risk being accepted. DOE's program is geared toward this type of process and it is doubtful whether the public will accept anything less.

CHAPTER 3

AN EVALUATION OF THE RELATIVE MERITS OF DISPOSING OF SPENT REACTOR FUEL VERSUS SOLIDIFIED HIGH-LEVEL WASTES

While everyone agrees that this country should safely and permanently dispose of high-level nuclear waste, there is substantial disagreement about whether that should include spent fuel or just the unusable part of the spent fuel that remains after chemical reprocessing. The most recently proposed solution by the previous administration was to dispose permanently of spent fuel without reprocessing. This was expected to restrict the availability of plutonium (which is separated from spent fuel during reprocessing) and thus limit the spread of nuclear weapons. However, representatives of the nuclear industry as well as others believe this solution is short-sighted and wasteful because the unused uranium and plutonium in spent fuel represent the energy equivalent of billions of barrels of oil.

While the disposal of spent reactor fuel without reprocessing offers short-term advantages for prohibiting the spread of nuclear materials, there is a possibility that over the long-term it will merely defer the proliferation problem to future generations. Furthermore, it is harder to permanently isolate spent fuel than solidified high-level waste. This is due to the thousands of years spent fuel remains toxic and potentially hazardous.

OPTIONS FOR MANAGEMENT OF SPENT POWER REACTOR FUEL

Nuclear power reactors operating today use only 1 to 2 percent of the energy potential contained in nuclear fuel. Before more can be used, the nuclear reaction creates certain undesirable materials called fission products which so significantly affect energy production that the fuel must be removed.

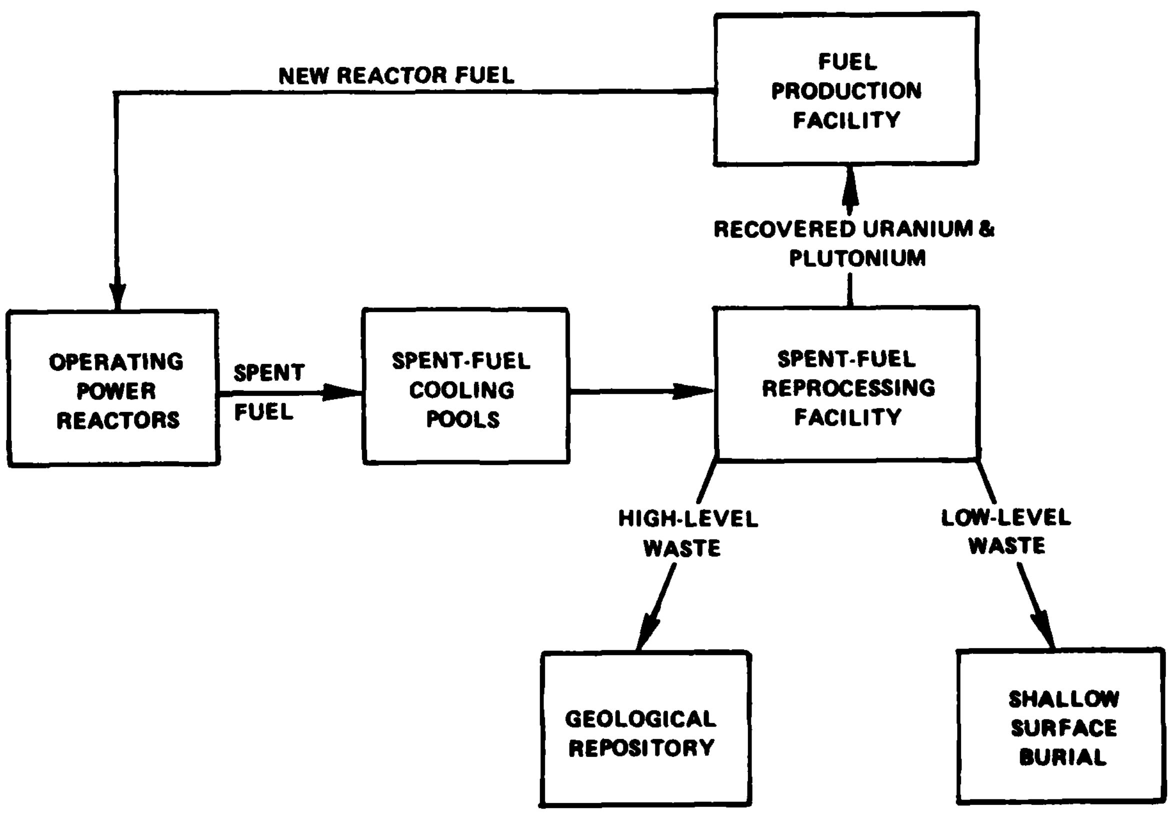
There are two basic options available for managing the spent fuel once it is removed from the reactor. One--called the "Recycle Option"--is to dissolve the fuel chemically, recover the uranium and plutonium containing the remaining 98 to 99 percent energy potential, and dispose of only the undesirable fission products and fuel cladding. The second

is the "Throw-Away Option" in which the spent fuel is disposed of without being reprocessed.

The recycle option

Typically, under this option, spent reactor fuel would be discharged from the reactor and stored in cooling pools at the powerplant sites for about 1 year. It would then be shipped in special containers to reprocessing plants where the uranium and plutonium would be recovered and the unusable, highly radioactive residues and unreclaimable chemical solvents would be solidified into a glass-like substance and placed inside steel containers. The uranium and plutonium would be sent to fuel fabrication plants and made into fresh reactor fuel. The solidified waste would continue to be stored for another 9 years at the reprocessing plant in near-surface storage facilities. This would allow the short-lived, high-heat-generating radioactive materials to decay, reducing the wastes' temperature tenfold. Finally, the cooled waste would be transferred to the Federal Government for disposal in an underground geologic repository. A schematic of the Recycle Option is shown in figure 1.

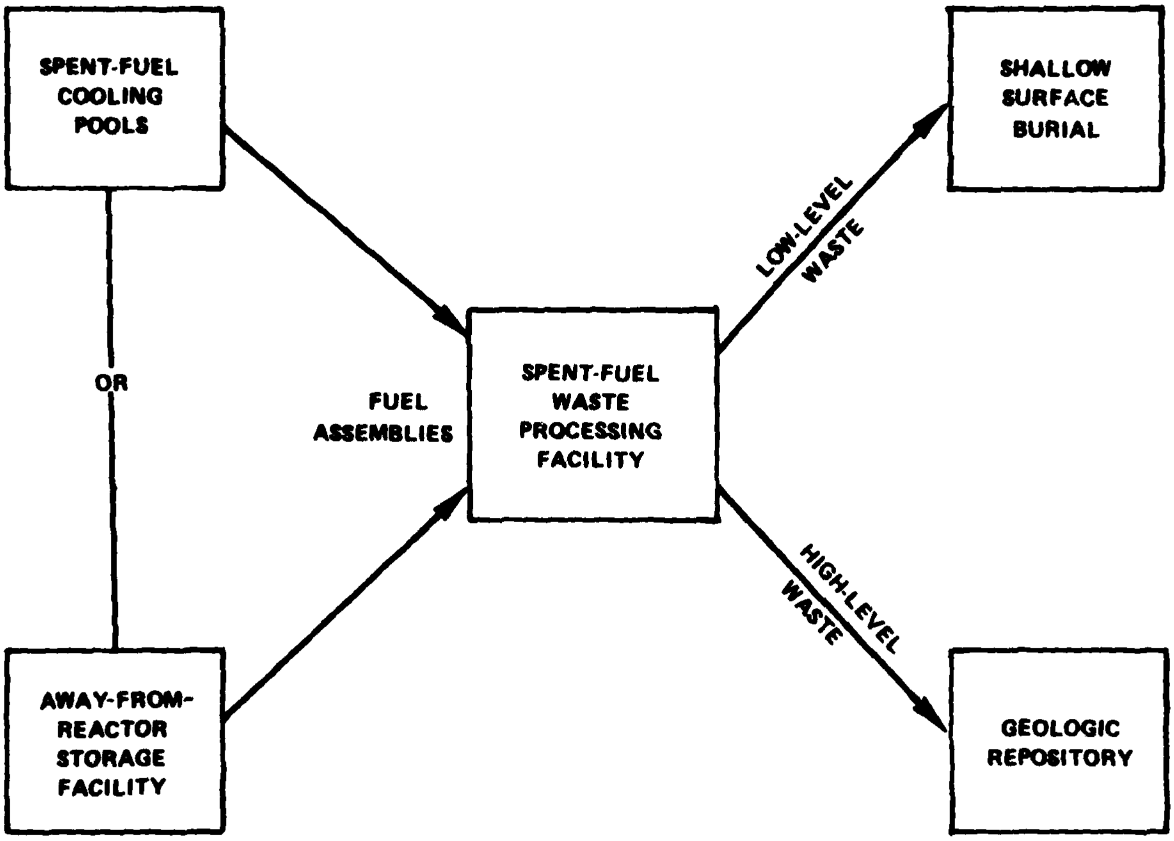
FIG. 1 - RECYCLE OPTION FOR SPENT FUEL



The throw-away option

Under this option the spent fuel would be stored at reactor sites or, if storage capacity is not available, shipped to away-from-reactor storage facilities. Here it would be stored for about 10 years until the heat generated by the spent fuel decreased to a level where it could be shipped to a waste preparation facility. It would then be placed in canisters for disposal in an underground repository. This option is shown in figure 2.

FIG. 2 - THROW-AWAY OPTION FOR SPENT FUEL



SPENT FUEL PRESENTS A GREATER DISPOSAL PROBLEM THAN HIGH-LEVEL WASTE

In developing the present nuclear waste management program, the previous administration assumed that spent fuel could be as easily stored or isolated from the environment as reprocessed high-level waste. To the contrary, we found that the form of the waste--spent fuel or solidified high-level waste--will have a significant influence not only on the location, design, and number of repositories, but also on the ability of DOE to assure isolation of the waste for the period of its toxicity.

According to NRC there are five distinct areas affecting the geological disposal of nuclear waste: (1) the potential for human intrusion into the repository, (2) the lifetime of the repository, (3) the physical size of the repository, (4) the interaction of the waste with the rock, and (5) the treatment of uncertainties. Disposal of spent fuel, as opposed to high-level waste, compounds each of these problems.

Spent fuel requires protective storage for many thousands of years

NRC believes that human intrusion into geological repositories cannot be prevented. Thus, to reduce reasons for such intrusions, NRC suggests that repositories be located at sites which have minimal resource value. However, disposal of spent fuel, with its large inventory of valuable uranium and plutonium, could turn otherwise useless sites into highly tempting targets for future human intrusion.

For instance, spent fuel from existing power reactors contains about 95 percent uranium, 1 percent plutonium, and 4 percent fission products and other elements. The uranium is highly refined and, if recovered, can be re-enriched and converted to reactor fuel. The plutonium, of course, is highly desirable either for reactor fuel or nuclear weapons.

Solidified high-level waste, on the other hand, consists almost entirely of fission products and other unusable elements, such as the fuel cladding and the non-radioactive additives used to solidify the waste. It contains only very small quantities (less than 0.5 percent)

of uranium and plutonium. The uranium, if recovered, would need to be either enriched or irradiated and reprocessed before it could be made into nuclear weapons. The plutonium would be very dispersed and difficult to recover.

An international team which studied waste management issues for the International Fuel Cycle Evaluation 1/ concluded that reprocessed high-level waste was relatively unattractive for producing nuclear weapons, and thus would not have to be extensively protected prior to its disposal. With respect to spent fuel, the team concluded that while it was unattractive initially because of the radiation barrier, the diversion risks, and thus the required safeguarding effort, would increase as the radioactivity decreased over time.

Disposal of spent fuel without reprocessing, therefore, may avoid the spread of nuclear weapons at this time, but it does not eliminate the threat. Instead, it creates, in effect, plutonium mines and defers the nuclear weapons proliferation threat to future generations.

Spent-fuel repositories must maintain their integrity much longer than high-level waste repositories

To render spent fuel nontoxic, it must be isolated from the environment for very long periods of time. This is because over 96 percent of its volume is made up of actinides. Actinides are heavy radioactive metallic elements, most notably uranium and plutonium, which decay to a nonradioactive state only after hundreds of thousands or millions of years.

Reprocessing, however, removes 99.5 percent of these actinides for re-use in commercial reactors. The remaining high-level wastes are made up principally of fission products and other elements which decay much more rapidly. In less than 1,000 years these fission products, plus the remaining traces of uranium and plutonium, will be less

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1/An international technical and analytical study of how nuclear energy can meet the world's energy needs, with special consideration of the needs of developing countries; and the measures which can and should be taken to minimize the dangers of proliferation of nuclear weapons without jeopardizing the peaceful uses of nuclear energy.

radioactive than the naturally occurring uranium ore from which the original reactor fuel was produced. The following graph shows the relative hazards of spent fuel and high-level waste to those of naturally occurring uranium ore. It compares the amount of uranium ore used to produce a metric ton of reactor fuel, with a metric ton of spent fuel and the waste from its reprocessing. The chart shows that after about 600 years the toxicity of high-level waste is equal to that of uranium ore, whereas it takes almost 10,000 years for spent fuel to decay to the same level. Thus, a geologic repository must maintain its integrity for a much longer period of time for spent fuel than for solidified high-level wastes.

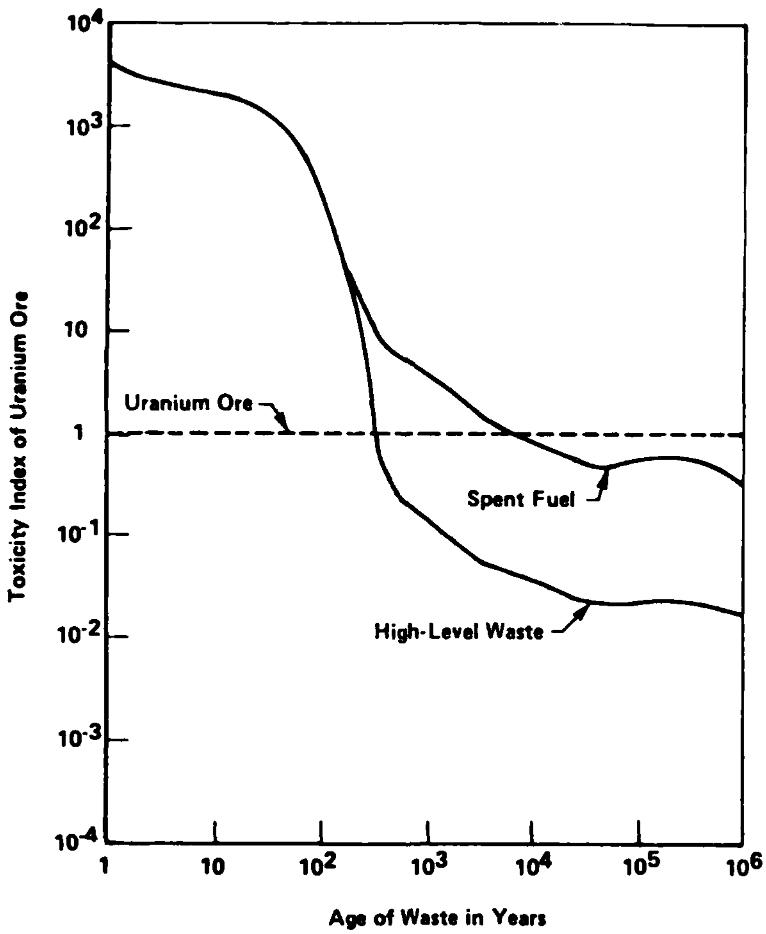

FIG. 3 – RELATIVE TOXICITY OF EQUIVALENT AMOUNTS OF URANIUM ORE, SPENT FUEL, AND HIGH-LEVEL WASTE

In addition, DOE is developing a series of engineered or manmade barriers which will surround the nuclear wastes and provide extra protection against the release of radioactivity to the environment. While these barriers should successfully isolate high-level wastes for 1,000 years, it is doubtful that they can contain spent fuel for the thousands of years it remains toxic. Instead, the geology must provide the necessary long-term containment for spent fuel.

Spent fuel cannot be tailored to meet the characteristics of the other components of the disposal system

Experts in high-level waste management believe that nuclear wastes should be compatible with the repository rock. This can be done by either tailoring the waste form to suit the rock or by finding a rock that is compatible to the waste form. Unfortunately, spent fuel is very complex and cannot be tailored to suit most rock forms. This makes its disposal more difficult than reprocessed high-level waste.

Nuclear fuel is designed for optimum performance within a reactor and not to meet any disposal criteria. Consequently, the heat and toxicity characteristics of each fuel assembly vary depending upon its position in the reactor core, its degree of burnup, and its age. Because of these variables, what may be an acceptable repository rock for one fuel assembly may not be acceptable for another. It is, therefore, necessary to fit the other elements of the disposal system (waste package and geological rock) to the heat levels of each individual fuel assembly.

High-level waste, on the other hand, is much more flexible. During reprocessing, a large amount of spent fuel is blended into a single, homogeneous mixture. The chemical makeup, the heat, and the radioactivity can be adjusted by adding or removing material before solidification. This permits the waste to be tailored to the desired waste form (glass, concrete, etc.), the container material, and the geological rock. Further, the solidified high-level waste is not susceptible to leaching and becomes a barrier itself, which is not true of spent fuel. In addition, the trapped radioactive gases in spent fuel, some of which are highly volatile, are removed from the high-level waste and themselves treated and solidified. This prevents their accidental release during operation of the repository. These gases may or may not be removed from spent fuel before their disposal, depending upon the process used to prepare the fuel for disposal.

Spent fuel disposal could require several times the repository space of solidified high-level waste

Because spent fuel consists mostly of uranium and plutonium, reprocessing and recovering these elements for re-use as reactor fuel greatly reduces the volume of high-level waste. Reprocessing does, however, create significant amounts of less radioactive (low-level) waste which normally is disposed of by shallow land burial. A DOE study estimated that the spent-fuel inventory on hand by 1993 would result in the waste quantities under three different methods of disposal as shown on the following page.

Another study done for DOE by Bechtel National, Inc., showed that a single 2,000-acre repository could dispose of all of the waste, including fuel cladding, 1/ associated with reprocessed spent fuels containing 200,000 metric tons of uranium. This represents the volume of spent fuel from about 170 reactors for 40 years. On the other hand, the study estimated that the disposal of the spent fuel without reprocessing would require three 2,000-acre repositories.

In commenting on a draft of GAO's report, DOE pointed out that its Environmental Impact Statement on the Management of Commercially Generated Radioactive Waste disagrees with the Bechtel study and states that spent fuel and reprocessed waste will require about the same repository space. The Bechtel study, according to DOE officials, assumes that non-heat producing transuranic waste (which results from the reprocessing operation) can be stored with the high-level waste, thus reducing the space requirement. DOE officials do not know whether or not this is feasible since no one has yet determined the effects that the heat generated by the high-level waste will have on the transuranic waste. Thus, DOE's environmental impact statement assumes that transuranic wastes will be put in separate repository locations, eliminating any spacing advantage that high-level reprocessed waste would have over spent-fuel. Consequently, we cannot conclude at this time whether the disposal of spent fuel will require more repository space.

SPENT FUEL--CHEAPER TO DISPOSE OF BUT TOO VALUABLE TO THROW AWAY

The Bechtel National, Inc., study mentioned above estimated that reprocessing the spent fuel and then disposing

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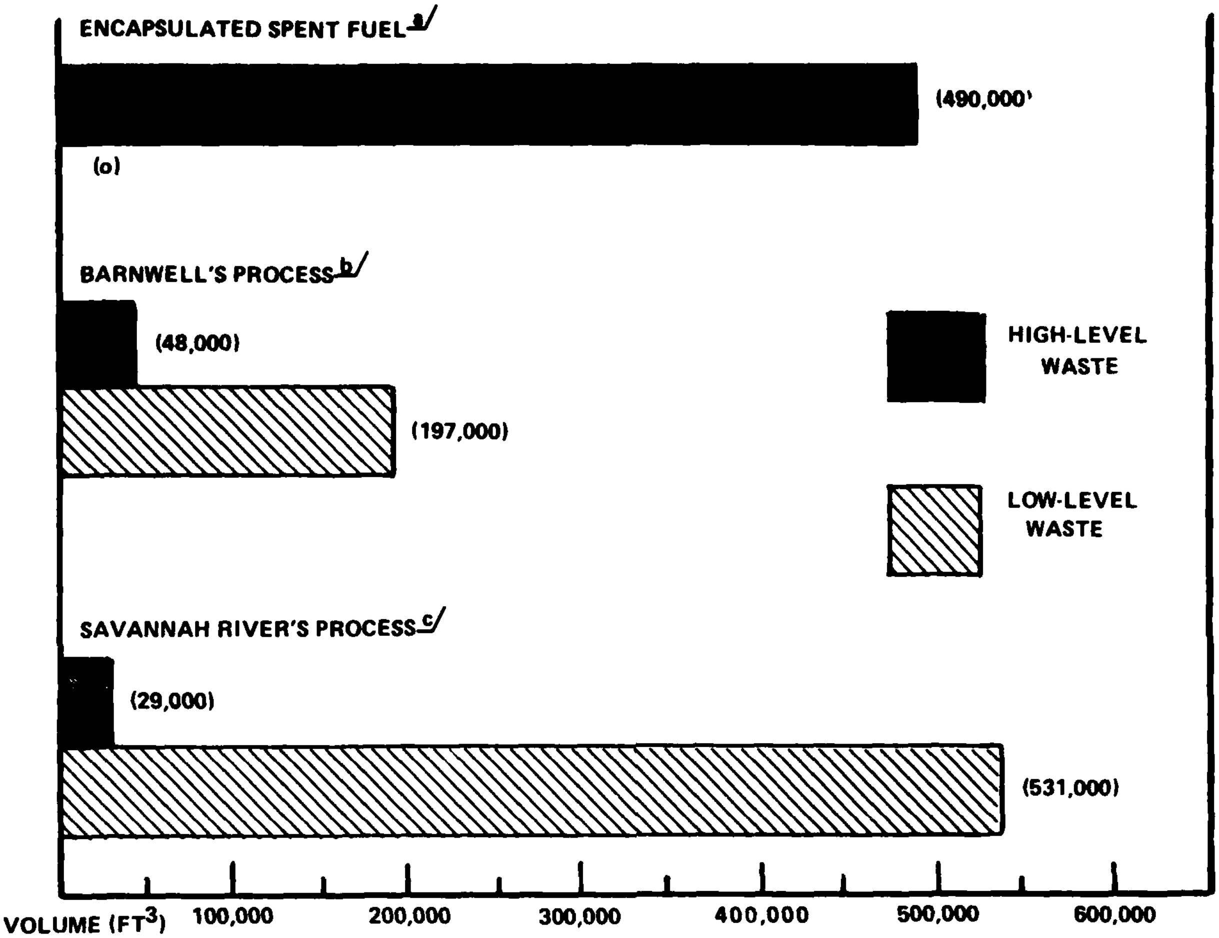
1/The long tubular or pipelike cases which hold the uranium fuel.

WASTE QUANTITIES AND TYPES FROM THREE

DIFFERENT SPENT FUEL DISPOSAL ALTERNATIVES



a/Spent fuel is encapsulated intact with no mechanical or chemical compaction.

b/Barnwell Nuclear Fuel Plant process, which includes intermediate level waste in the solidified high-level waste.

c/Savannah River concept, which fixes intermediate level waste in concrete as a part of the low-level waste.

of the resultant high-level waste would be significantly more expensive than simply disposing of spent fuel. The study showed, however, that if the value of the recovered uranium and plutonium were offset against the reprocessing and disposal costs, a substantial net profit could be realized.

For example, using 1979 prices with a 10-percent discount rate and a 40-year study period, the costs of disposing of spent fuel were:

--$116,000 per metric ton if spent fuel is encapsulated intact;

--$115,000 per metric ton if spent fuel is mechanically compacted and gases are removed before encapsulation; and

--$167,000 per metric ton if spent fuel is dissolved and solidified in containers.

On the other hand, reprocessing the spent fuel and solidifying and disposing of the wastes were estimated to cost $186,000 per metric ton. The value of the recovered uranium and plutonium, however, was estimated to be $130,000 and $210,000, respectively, resulting in a net profit of $154,000 per metric ton of uranium for this option.

We reviewed several studies and analyses on the economics of reprocessing, none of which was as comprehensive as the Bechtel study. While most of these studies agreed that it was economical to reprocess spent fuel, the extent of the economic advantages differed with basic assumptions or values assigned to the variables.

The value of the recovered uranium and plutonium should not be measured in monetary terms alone. Their potential for extending domestic energy supplies is very large. For example, one estimate places the energy value of the uranium and plutonium in all the spent fuel accumulated in the United States by the year 2000 at the equivalent of 15 billion barrels of oil--one and one-half times the estimated amount of oil in Alaska's North Slope. This estimate assumes that the uranium and plutonium would be recycled in current-generation light water reactors. A representative of a utility industry research institute estimated that if this material were recycled in breeder reactors, the energy value would be 60 times this--or 900 billion barrels of oil.

CONCLUSIONS

If spent fuel is not reprocessed, the plutonium will remain bound in the spent fuel and cannot be used to make nuclear weapons. From this standpoint, disposal of spent fuel appears to be desirable. Disposing of spent fuel, however, does not necessarily eliminate the proliferation problem--it might only defer the nuclear weapon threat to future generations who may exhume and reprocess the fuel. Furthermore, failure to reprocess spent fuel at this time complicates the already difficult task of disposing of nuclear waste. It precludes reliance on engineered barriers to contain the waste until it is no longer a hazard, prevents tailoring the waste to the other components of the waste disposal system, requires significantly more repository space, and wastes a very valuable resource.

CHAPTER 4

CAN MANMADE BARRIERS PROTECT AGAINST THE RELEASE OF RADIOACTIVITY?

DOE's geological repository program is directed toward proving that high-level nuclear wastes can be isolated from the biosphere for very long periods of time (if not permanently). In this respect, DOE is studying various types of rock formations at several potential locations, trying to determine which might be best suited to house a repository. During the past 2 years, DOE (to meet proposed NRC licensing criteria) has placed increased emphasis on designing a series of manmade barriers to further guarantee that the wastes can be kept isolated once placed in a repository.

These barriers, known as the "waste package," are supposed to contain radioactive elements for a time period established by NRC--currently proposed as 1,000 years. To meet this criterion, DOE has been studying different types of containment materials under the conditions expected in a repository (i.e., normal heat, pressure, water, and radiation) as well as under abnormal or unexpected conditions.

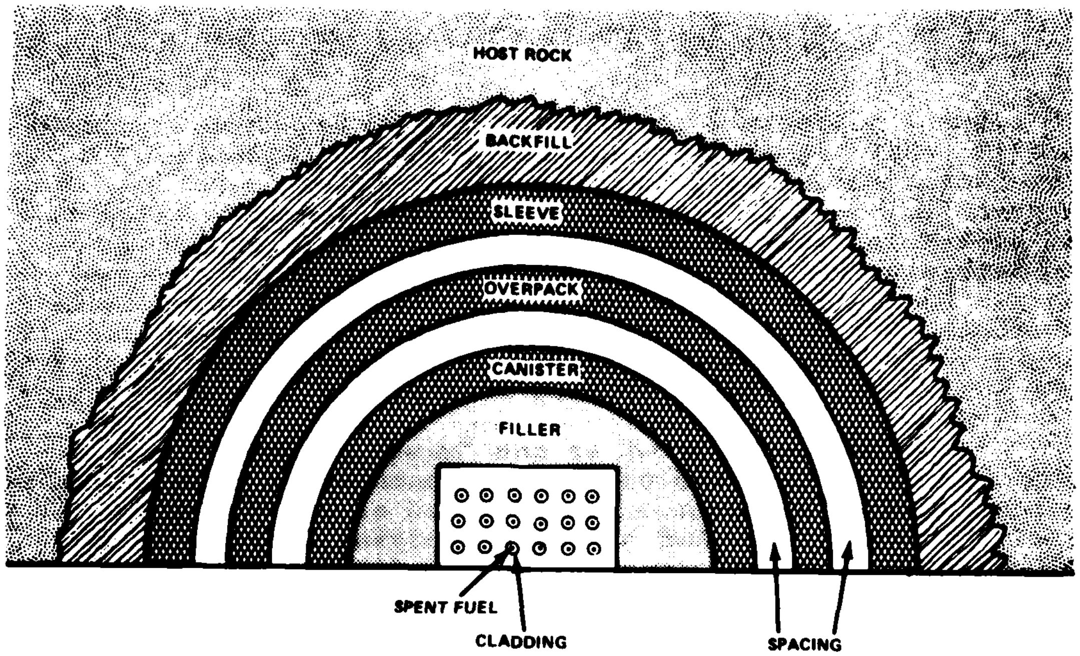
Based on the information obtained to date, DOE's contractors and scientists believe that a waste package can be designed that will completely contain either spent fuel or high-level waste for 1,000 years. Because of the extended toxic life of spent fuel, however, the geology must serve as the primary barrier between it and the biosphere. The waste package offers little long-term advantage in this case. High-level waste, on the other hand, decays before 1,000 years to the radioactive level of naturally occurring uranium ore. Thus, the waste package offers major advantages in the disposal of high-level wastes.

NRC REQUIRES A WASTE PACKAGE

As part of its draft technical criteria NRC is requiring that DOE provide assurances that the geology will remain stable for the next 10,000 years and guarantee that the wastes will be contained for at least 1,000 years within a manmade barrier system--called the waste package.

The waste package, illustrated on the following page, includes everything that will go into a drilled hole in the floor of a repository. This package is supposed to provide an extra measure of protection by completely

containing the radioactive wastes for their first 1,000 years in the repository.



CONCEPTUAL WASTE PACKAGE
FOR SPENT FUEL 1/

From the inside out, the package will include

--the nuclear waste, put into a form which immobilizes the radioactive materials and resists leaching, powdering, or other modes of degradation;

--several canisters which act as structural supports and prevent ground water from reaching the nuclear wastes; and

--a material which absorbs radioactive particles that could leach out or water that might find its way into the respository.

1/The package for high-level waste is the same, except that a solid form (glass, ceramic, concrete, etc.) would replace the filler and spent fuel.

Although a repository will be built in a rock formation that is as void of water as possible, the principal means by which radionuclides could reach the accessible environment is through potential future contact with circulating ground water.

STATUS OF THE WASTE PACKAGE PROGRAM

The next three sections discuss the status of DOE's research and testing program for the different components of the waste package. In each case, DOE is assuming worst case situations in determining the ability of the component to contain the waste.

Developing an acceptable waste form

In developing an acceptable waste form, DOE is dealing with two types of materials. One is spent fuel, which is already in a solid form and might require very little preparation or processing before disposal. The other is high-level liquid wastes which must be solidified or put into a form more suitable for isolation. DOE has for several years been studying potential solidification schemes. The theory, which has been demonstrated by DOE, is that the liquid wastes would be solidified into a powder, mixed or dispersed into some type of melted substance, and poured into metal containers for eventual disposal.

Most of DOE's efforts in this area have been directed toward finding the most suitable material in which to mix the powdered waste. It has studied five ceramic, three glass, and two concrete forms, and a metal/ceramic one. A peer review group selected by DOE and made up of eight university and industry members concluded that borosilicate glass is the most practical and technically feasible of all the forms being studied. Other countries with nuclear waste programs have already judged borosilicate glass as the best candidate for immobilizing high-level wastes. Nevertheless, DOE is not completely satisfied with this glass and is continuing its research on other types of possible waste forms.

Thus, under the current schedule, DOE plans to continue research on all candidate waste forms through fiscal year 1981. At that point, three or four of the most promising waste forms will be selected for intensive development. At the end of fiscal year 1983, one or two waste forms will be selected for full-scale development and final designs will be completed for a high-level waste solidification facility at DOE's Savannah River National Laboratory. In

total, the cost of research on candidate waste forms will be about $90 million between now and the end of fiscal year 1983, if continued at the presently planned level.

It is almost certain that DOE will select borosilicate glass as the solidification medium. In fact, DOE already has a demonstration project underway to develop the process and equipment needed to immobilize high-level waste in borosilicate glass--at a cost of $28 million through fiscal year 1981. DOE believes, however, that it must continue research on other potential waste forms to satisfy National Environmental Policy Act requirements and to guarantee that borosilicate glass is, in fact, the best medium for isolating high-level wastes.

Multiple canisters to help isolate nuclear wastes

In addition to the waste form, there are three canisters in the proposed waste package: the waste form canister, overpack canister, and sleeve. They are supposed to provide physical strength, help contain the waste for at least 1,000 years, and simplify retrievability, if that proves necessary. DOE has been studying potential canister materials for several years and research is still continuing in hopes that more favorable materials or techniques will be found before the first repository is opened. Equally as important, however, DOE is developing as much information as it reasonably can on the material in hopes that it will better enable them to satisfy future NRC licensing criteria. Because these criteria are not yet established, DOE feels that it must prove material acceptability under the worst situations expected in a repository.

The waste form canister

The primary purpose of the waste form canister is to provide structural stability during the temporary storage, transportation, and/or permanent isolation of the waste form. To a lesser extent it will also help keep the waste form isolated from the repository rock for the 1,000-year period being required by NRC. For the most part, however, waste isolation will be guaranteed by the other canisters and parts of the waste package.

The best waste form canister material found to date by DOE is stainless steel. It is being used in DOE demonstration projects and provides not only the physical strength necessary for transportation and repository conditions, but also is unaffected by potential waste heat .

and radiation. DOE is continuing to evaluate stainless steel as well as other materials.

DOE still needs to complete canister designs for the disposal of spent fuel. Unlike solidified high-level waste, which will be poured into the waste form canister, spent fuel will not occupy the entire area inside the canister. Consequently, some sort of stabilizing material will have to fill the empty spaces and equalize the outside pressure on the canister. While much work is yet to be done, DOE expects that some type of inert gas, such as helium, or a glass or metal which can be melted and poured in the empty spaces will be used.

The overpack canister--corrosion resistance for 1,000 years

The second canister is the overpack canister. This will be placed around the waste form canister, probably at the repository site, to isolate the wastes from water that might enter or already be in the repository. The overpack canister must be made of materials that are highly corrosion-resistant.

Sandia Laboratories has performed most of the materials research for this canister material. Sandia believes this alloy by itself will protect the wastes from circulating ground water for most of the 1,000-year period required by NRC. This means that if all the other waste package materials lost their isolation properties, the overpack canister would still keep the wastes separated from ground water.

However, DOE is continuing research on the alloy to further establish its acceptability and assess its ability to resist spot corrosion or pitting. Other materials are being tested in case a deficiency is found in the alloy.

The sleeve provides retrievability

The last canister layer in the waste package is the sleeve. This is another metal container designed to provide both structural support and corrosion resistance, but its primary purpose is to foster retrievability. According to draft NRC licensing criteria, a repository must be designed so that the waste can be easily retrieved (within the first 50 years) if necessary for health or safety reasons. Thus, the sleeve will be built into a repository so that the waste form and first two canister layers can be inserted and removed with relative ease.

The materials being considered for the sleeve are basically the same as for the waste form and overpack canisters. In addition, other materials such as cast iron, mild steel, special-coated concrete, and reinforced polymers are being considered.

Backfill--the final layer of the waste package

All geologies being studied by DOE contain some traces of water. In some geologies the water could be drawn to the canister by the heat of the nuclear waste; in other geologies it will move at its normal rate through the repository. DOE, therefore, is proposing to place a special "backfill" material between the sleeve and the host rock to absorb the water and reduce the potential that it will come in contact with and corrode the canisters.

In addition, the backfill will absorb the movement of radionuclides if the waste should come in contact with water and be carried out toward the rock. In fact, tests have shown that under expected repository conditions, the backfill will absorb all short-lived fission products that could leach from the waste package during the first 1,000 years of disposal. By this time the fission products will have significantly decayed and will no longer be a major threat to public health and safety. Tests at Sandia Laboratories have also demonstrated that the backfill will absorb the longer-lived radioactive elements (such as uranium and plutonium) for at least 10,000 years and possibly 100,000 years. After this period continued isloation will be dependent on the geology.

To date, however, most tests have been conducted in salt using a variety of special absorbing materials. As a result, DOE has found that the best backfill material (at least for salt) is a type of clay mixed with the absorbing materials such as sand and charcoal. More work needs to be done to tailor the backfill material to other types of geologies.

CONCLUSIONS

DOE's contractors and scientists believe it has developed the technology to safely contain high-level waste and spent fuel for the 1,000-year period proposed by NRC. However, the waste package cannot be expected to last long enough to contain spent fuel beyond its toxic period. Thus, reliance must be placed on the geology to contain the spent fuel.

DOE is attempting to provide information to convince NRC that the technology is sound. Since the NRC criterion is not final and a need exists for alternative materials to satisfy the National Environmental Policy Act, DOE is continuing to search for better materials and design.

CHAPTER 5

CONCLUSIONS AND OBSERVATIONS

Over the past decade, increasing social and political pressures have prompted the Federal Government to establish a workable nuclear waste disposal program. The main objective of this program is to construct a waste repository below the earth's surface, which will accommodate commercial spent fuel, reprocessed high-level waste from commercial spent fuel, and defense high-level waste. This repository will include large storage rooms in deep underground geological formations, access shafts to the storage rooms, and surface handling facilities to encapsulate the waste and prepare it for burial. DOE, subject to NRC's licensing authority, is responsible for all phases of the waste disposal program including (1) site selection, (2) waste preparation, and (3) repository design, construction, and operation.

To carry out this mission and to insure that the wastes remain isolated for as long as possible, DOE is developing and analyzing information on different types of repository designs, waste canister materials, and geological rock formation. Central to the program are DOE's efforts to find the best possible repository site. This site should have very little water, be situated in stable geology, and be capable of maintaining its stability under expected heat and radiation emitted from the waste.

We believe that DOE's present technical waste program is making progress. DOE believes, and we tend to agree, that the major obstacle to geological disposal is not the technology, but public and political acceptance of the waste disposal concept and of the localities where the repositories will be located. As such, one of DOE's program objectives is to research potential problems and resolve the public fears associated with nuclear waste disposal. DOE believes this will provide, under current schedules, the first geological repository sometime between 1997 and 2006.

One of the major controversies associated with DOE's waste management program is the handling of spent fuel. At present, DOE is planning to bury it as a nuclear waste. Some experts and political leaders believe, however, that spent fuel may be too valuable a resource to throw away and that its disposal creates special waste isolation problems.

We have found that spent fuel does indeed create problems that make its isolation more difficult. For instance, it contains mostly long-lived radionuclides, such as plutonium

and uranium, which remain toxic for hundreds of thousands of years. This requires almost complete reliance on the geology to contain the wastes for the period of their potential hazard. No manmade barrier can be constructed which will guarantee isolation for this period of time. High-level waste, on the other hand, has most of these long-lived elements removed during reprocessing, and it decays to the radioactive level of naturally occurring uranium ore in about 600 to 1,000 years. DOE contractors believe that they can fabricate a barrier system which will completely contain the wastes for this period of time, offering greater assurances that the wastes will not reach the accessible environment during the period of their greatest toxicity.

In addition we found that spent fuel

--unlike high-level waste cannot be tailored to give uniform and acceptable levels of heat generation, which makes it more difficult to prove the long-term integrity of the repository;

--could require three times as much area in a repository as reprocessed high-level waste;

--will cost more to dispose of than high-level waste, considering the value of the uranium and plutonium recovered during reprocessing;

--is a valuable energy resource, particularly if other advanced energy technologies under development do not progress as expected; and

--even when disposed of does not eliminate the proliferation problem but merely transfers it to future generations who might find it necessary to exhume the spent fuel for whatever purposes they consider necessary, including the manufacture of nuclear weapons.

Thus, when considering only the impact on nuclear waste disposal, it makes sense that spent fuel not be buried in a repository but instead be reprocessed to recover the valuable uranium and plutonium. Unfortunately, however, the solution to the reprocessing question cannot be based solely on the waste disposal issue.

A more fundamental issue is the future role that commercial nuclear power will play in this country. If nuclear power is

intended only to serve as a stop-gap energy alternative until other advanced technologies are developed, there is no question that spent fuel will not be needed and must eventually be buried or otherwise isolated from the accessible environment. But if commercial nuclear power makes a strong comeback and fulfills the predictions from its early development, spent fuel will be a valuable resource, worth the equivalent of billions of barrels of oil.

Thus far, the United States as a country has been ambivalent about the future of commercial nuclear power. On the one hand, the country recognizes that nuclear power has the potential (through development of the breeder reactor and other advanced nuclear technologies) to provide all of our electricity needs for centuries, while on the other hand there are still concerns about the many potential or perceived safety and environmental hazards of nuclear power. Thus, its future at this point may be bright or bleak depending upon the development of other energy alternatives, the resolution of perceived safety concerns and public fears, or the attitudes of present and succeeding administrations toward nuclear power.

Therefore, until the Congress makes a decision on the future of nuclear power, DOE has no option but to plan for any eventuality--including the potential geologic disposal of spent fuel. To do anything less would be a failure to carry out its waste isolation responsibilities. Other long-term storage options are available, however, which would keep spent fuel above ground and easily accessible for future use. DOE's consideration of these options would guarantee that the United States is able to handle any eventuality regarding the future need for nuclear power.

THE DEPARTMENT OF ENERGY'S APRIL 10, 1981, COMMENTS ON A DRAFT OF THIS REPORT AND GAO'S EVALUATION OF THE COMMENTS

DOE Comments 1/

The Department of Energy appreciates the opportunity to review the General Accounting Office (GAO) draft report entitled "Which Is Simpler To Permanently Dispose Of--Spent Fuel Or Waste From Reprocessed Spent Fuel." It is the Department's understanding that the report was to address two specific questions which are as follows:

1. Is spent fuel simpler to dispose of than waste from reprocessed spent fuel?

2. Will the use of modern materials in man-made barriers contain the waste (both spent fuel and high-level) until they decay to the level of naturally occurring uranium?

The Department believes that the report has adequately addressed these questions and has established several reasonable conclusions. The Department agrees with the overall conclusion that spent fuel is not necessarily the optimum waste form from a disposal viewpoint when compared with other waste forms currently under development. However, this conclusion is reached using elementary analysis and does not consider the relative impact on man from disposal of either type of waste. The conclusion that it will be simpler to dispose of processed high-level waste is based totally on the logistics and mechanics of disposal; it does not include considerations of the waste isolation system's capacity to assure safety.

GAO Evaluation

We do not agree that our analysis was elementary and we do believe the draft does fully compare the potential impact on man from disposing of both types of wastes. For example, chapter 3 specifically focuses on the disposal of both wastes in terms of economics, health and safety assurances, proliferation, land use requirements and the degree to which future health and safety can be assured. We believe these topics have a major impact on man, both now and in the future.

1/Page number references in DOE's comments have been changed to reflect final report.

safety." In explaining this comment, DOE officials said that information developed to date suggests that both spent fuel and high-level wastes, despite their differences, can be safely isolated within a total isolation system (i.e., a combining of naturally occurring geologic formations and manmade barriers). DOE officials believed we should have expressed this view.

Unfortunately, however, the total isolation system was not the subject of our review nor was it something we could have concluded based on the status of the waste disposal program. While much research has been done, DOE and contractor officials are not yet convinced that the relative safety of spent fuel and high-level waste disposal can be unequivocally demonstrated--at least not to the satisfaction of NRC. As highlighted in our scope section, we chose to consider only the relative difficulty in disposing of both types of waste and not the ability of the repository to insure long-term isolation.

DOE Comments

The Department is strongly supporting reprocessing of commercial spent fuel rather than its disposal as waste. Secretary Edwards outlined the Department's policy on re-processing and storage of spent fuel in testimony before the Senate Armed Services Committee on March 13, 1981, saying, "So far as reprocessing goes Senator (Thurmond), I feel strongly that this is one of the things we have to do. The President is particularly interested in (industry) moving into the reprocessing business."

While the Department is in general agreement with the major conclusion of the report, certain positions need to be clarified and some comments about the report's focus need to be considered. The report openly acknowledges (page 7) the need for a clear focus on the questions raised.

Despite this acknowledgement there appears to be considerable drift in the scope of this discussion. Examples of extraneous issues addressed are:

a. Defense high-level waste stored as liquid in tanks and the leaks experienced in previous years (pages 1, 2, 5, and 10);

b. The need for an exploratory shaft as a prerequisite for site selection.

The points noted above are indeed important to the conduct of the total program, but it is not clear how their inclusion in the report facilitates the analysis of the disposal of spent fuel. The Department would particularly like to request that reference to the defense waste management activities be deleted since there appears to be no connection between that program and the disposal of spent fuel from commercial power reactors.

GAO Evaluation

We believe that 100 million gallons of defense high-level waste, some of which has been stored for 35 years, is not an extraneous issue and is relevant to the commercial spent fuel disposal program, for two reasons. First, it is very likely that the first repository will be capable of accepting defense waste as well as others. Since defense waste is in a mobile liquid form and has leaked in the past, we believe that a need exists for its timely disposal. Secondly, defense waste is similar to commercial processed waste in many ways. They both contain fission products, are in liquid form, generate heat and radiation and must be converted to a solid and placed in a container before disposal. Also, from a health and safety perspective, the public does not care what label is put on the waste--defense or commercial. Thus, it seems very clear there is a connection between commercial and defense waste. Since the two wastes are similar we do not believe a separate disposal technology or repository is necessary. It would only add cost to an already expensive program.

The discussion of exploratory shafts in our report has been deleted because the NRC has issued final regulations which require construction of shafts at potential sites before they can be licensed.

DOE Comments

Chapter 3 appears to be the most important section in presenting the arguments about the disposal of spent fuel versus high-level processed waste. Some very good points are raised, but the data used to support the contentions are not necessarily conclusive. For example, it is concluded that spent fuel repositories must maintain their integrity much longer than high-level waste repositories. The position appears to be based solely on the analysis of the relative toxicity of radionuclides in spent fuel and processed high-level waste. The Department would strongly suggest that this contention be confirmed by other supporting analysis of the isolation capability of

the repository. A consequence analysis of this type was done for processed high-level waste and spent fuel repositories for the International Nuclear Fuel Cycle Evaluation and it showed that the consequences of either, under normal and accident conditions, were not significant.

GAO Evaluation

Chapter 3 points out that processed high-level waste decays in about 600 years to the toxicity of the natural uranium ore used in its production. It also points out that spent fuel, because of its large concentration of long-lived radioactive materials, takes about 10,000 years to reach the same level. Therefore, we concluded that it is more important that a spent fuel repository maintain its integrity than one containing only processed waste.

The NRC discusses the same point in the background section of its proposed rules published in the Federal Register on May 13, 1980. The NRC states that after the short-lived fission materials are no longer hazardous the geology will be relied on to limit releases of long-lived materials to the environment. NRC further states that long-term stability of the geology must be assessed and determined. DOE's comments suggest that both spent fuel and high level waste disposal can be achieved at the same level or degree of safety. While this may be true, DOE has not yet developed enough information to make such a conclusion. We believe that providing information to prove the long-term stability of the geology is very difficult and some uncertainties may never be resolved.

DOE Comments

The conclusions drawn at the end of Chapter 3 seemed to be based on the prerequisite that the waste package contain the waste for a period while its relative toxicity is greater than that of uranium. It is not clear why this is a prerequisite for the General Accounting Office since it is not a prerequisite in the Nuclear Regulatory Commission's regulations or the Environmental Protection Agency's standard. Before this requirement is specified by the General Accounting Office, the rationale behind this technical requirement, specifically how failure to comply with it would affect mankind, should be more carefully evaluated.

GAO Evaluation

The GAO has not set a prerequisite that the waste package contain the waste for the period while its relative toxicity is greater than that of naturally occurring uranium ore. It is used merely as a reference point in this report as in many other studies. The NRC has proposed regulations which require a waste package to contain the waste for 1,000 years. The 1,000 year period (according to available data) is sufficient to allow processed high-level waste to decay to the toxicity of the natural uranium ore used in its production. However, the 1,000 year period is not sufficient time for spent fuel to decay to the same level. In this respect, DOE is studying various geologies to assure repository integrity beyond the 1,000 period. We conclude at the end of chapter 3 that failure to reprocess spent fuel at this time complicates the already difficult task of disposing of nuclear waste. It precludes reliance on engineered barriers to contain the waste until it is no longer a major hazard.

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In addition to the general comments addressed above, the DOE has listed several specific comments which we are addressing separately below.

DOE Comments

The Department believes the objectives of the NWTS (National Waste Terminal Storage) Program have been overstated in several places. Below the Department has noted these statements and has provided a more accurate statement of its objectives:

a. The Department is not attempting to resolve all unknowns as the basis for implementing a waste repository (page 4). The Department is attempting to resolve the specific uncertainties necessary to assure the long-term isolation of the waste.

GAO Evaluation

The report has been changed to acknowledge that DOE is not attempting to resolve "all" unknowns but only those that are significant or important to the waste isolation program.

DOE Comments

The Department is not attempting to identify the best possible disposal technology and repository site (page 4). The Department is attempting to develop the technology and identify repository sites that will safely isolate waste from man and his environment.

GAO Evaluation

The DOE has publicly stated that a safe disposal technology already exists. Yet it is spending about $100 million annually on waste disposal technology. We believe the effort must be geared toward identifying the best possible technology. We also believe that since NRC's criteria requires that DOE select a preferred site for licensing, it will be the best qualified site that DOE can identify.

DOE Comments

The Department did not assume that spent fuel could be isolated from the environment as easily as processed high-level waste (page 25). The Department considered the technical problems and times necessary to assure that releases from a repository would not affect mankind. Consequence analyses have shown that either waste form can be effectively contained in a waste repository under normal and accident conditions.

GAO Evaluations

We agree that DOE did not assume that spent fuel could be isolated from the environment as easily as high-level waste. However, the administration's decision to dispose of spent fuel as waste was based on limiting the spread of nuclear weapons. It did not consider other factors, such as the additional difficulties involved in spent fuel disposal. We have changed the report to reflect that the administration made the assumption. DOE's comment on the consequence analysis, which appeared in a previous comment, has already been addressed.

DOE Comments

The General Accounting Office report states that the Department believes that it has the technology to fabricate a waste package system which will contain the waste for 1,000 years (pages 33 and 38). Some scientists and engineers within the Program have expressed this optimism,

but the Department is not yet assured that this position can be demonstrated to the satisfaction of a regulatory body.

GAO Evaluation

We agree with this comment in that we were told this by some scientists and engineers within DOE's program and have so stated. We also state in the conclusion to chapter 4 that "DOE is attempting to provide information to convince NRC that the technology is sound." Thus, we believe that we have fairly presented DOE's position on the waste package.

DOE Comments

The Department is not presently planning to bury spent fuel as nuclear waste (page 40). Bury is a term that connotes shallow land disposal suitable only for low-level waste. The Department is developing the capability to dispose of spent fuel should that be required. Even in a reprocessing nuclear economy, every spent fuel element may not be reprocessed. Decisions to dispose of or reprocess spent fuel will be made by the owners of that fuel depending upon the relative value of the fuel compared to the cost of its recovery. For technical or other reasons, it is expected some fuel will go directly to permanent disposal.

GAO Evaluation

The word bury means "to dispose of by depositing in the earth." We believe the report fully explains the repository concept and no change is necessary. Otherwise, we agree that DOE may eventually have to dispose of some quantity of spent fuel, even if reprocessing technologies exist. Thus, it seems logical that DOE should continue to study and plan for that eventuality.

We do not believe, however, that the decision to dispose of or reprocess spent fuel will be made solely on economics. As discussed in chapter 5, the decision will be based on the future role of nuclear power in this country.

DOE Comments

The Department no longer has an Office of Nuclear Waste Management (page 4). The title of the operation has been changed to Nuclear Waste Management Programs.

GAO Evaluation

GAO agrees and has changed the report to read the Nuclear Waste Management Programs.

DOE Comments

The Office of Nuclear Waste Isolation (ONWI) has not divided the United States into 11 provinces for the purposes of siting studies (page 11). This sounds like the approach proposed by the United States Geological Survey.

GAO Evaluation

We agree with DOE that the U.S. Geological Survey is conducting the program. We were told by ONWI officials in August, 1980 that they planned to assist on the studies in some provinces. A recent check with ONWI officials indicated they did not proceed with this plan because of State concurrence problems. The report has been changed to reflect this information.

DOE Comments

The conclusion about the suitability of borosilicate glass applies to the defense waste at Savannah River only (page 35).

GAO Evaluation

In chapter 4 we state that a peer review group selected by DOE made up of eight university and industrial members concluded that borosilicate glass is the most practical and technically feasible of all waste forms being studied. The judgement made by this group applied to both defense and commercial waste. The group also stated that the primary difference between the use of glass for commercial versus defense wastes is the heat generated by the commercial waste which is easily accommodated with corresponding reductions in the amount of waste mixed in the glass. Although the two wastes may be different in this respect, as discussed in chapter 3 they can be tailored to meet certain repository requirements.

DOE Comments

Several technical points need to be resolved or clarified in the final document. They are as follows:

In a Federal processing plant the spent fuel is not chopped (page 2). The spent fuel is not liquefied; the entire fuel element is dissolved in acid. The Department has restated the points here to promote understanding of how the processing is done in a Federal facility. However, the point is not relevant to the discussion of a commercial reprocessing plant and should be deleted from the report.

GAO Evaluation

We agree that in a Federal reprocessing facility the fuel is not chopped as it would be in a commercial reprocessing plant, but rather dissolved in acid. We used the word "liquefied" to help the reader more clearly understand the process. The liquid acid used in the process only separates the materials and does not liquify it. The report has been changed accordingly.

We did not delete the section on Federal reprocessing because it is the only reprocessing being done at this time that can be used to acquaint the reader with the process.

DOE Comments

The report confuses the use of the terms "isolation" and "containment" throughout the document. For GAO's reference the Department defines the terms in the following manner:

isolation - separation of waste from the accessible environment (biosphere).

containment - confining the radioactive wastes within the prescribed boundaries, e.g., within a waste package.

GAO Evaluation

We could find no place in the report where use of the two terms is confusing.

DOE Comments

The analysis of the space in a repository for processed high-level waste has not included the disposal of transuranic waste from the commercial fuel cycle which will also have to be placed in geologic repositories (page 29).

Please refer to the analysis in the Final Generic Environmental Impact Statement entitled "Management of Commercially Generated Radioactive Waste" DOE/EIS-0046 (Volume 1, page 1.9). This question is pivotal to the General Accounting Office's argument. It should be reconsidered prior to drawing a definitive conclusion on which approach needs the least repository area.

GAO Evaluations

Contrary to DOE's comment, the study referenced in the report does include the transuranic waste and is so stated. The report states the Bechtel National, Inc., study showed that a single 2,000-acre repository could dispose of all the waste, including fuel cladding and other waste associated with reprocessed spent fuel containing 200,000 metric tons of uranium.

The analysis in the Environmental Impact Statement concludes that more space will be needed for high-level waste than spent fuel. The difference in the two DOE studies is the assumption made about storing the transuranic waste. The Bechtel National, Inc., study, which cost DOE about $2 million, assumes that since the transuranic waste produces no heat it can be placed in the storage rooms with the high-level waste. The Environmental Impact Statement assumes the transuranic waste is placed in separate rooms. This assumption was used because no one has studied the effect the heat from the high-level waste might have on the transuranic waste if they are stored in close proximity.

We believe this is an important point since each repository is expected to cost $2 billion to $4 billion dollars. Since the two DOF studies present conflicting information, we cannot at this time draw a definitive conclusion and have recognized this in the report.

DOE Comments

The radionuclides in spent fuel will not remain toxic for millions of years (page 6) according to the figure on page 27.

GAO Evaluation

The graph on page 27 shows that spent fuel will remain toxic for a million years. It also shows that high-level waste remains toxic for the same period but is less toxic than the spent fuel. We changed the report to make this point clear.

Department of Energy
Washington, D.C. 20585

APR 10 1981

Mr. J. Dexter Peach
Energy and Minerals Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Peach:

The Department of Energy appreciates the opportunity to review the General Accounting Office (GAO) draft report entitled "Which Is Simpler To Permanently Dispose Of--Spent Fuel Or Waste From Reprocessed Spent Fuel." It is the Department's understanding that the report was to address two specific questions which are as follows:

1. Is spent fuel simpler to dispose of than waste from reprocessed spent fuel?

2. Will the use of modern materials in man-made barriers contain the waste (both spent fuel and high-level) until they decay to the level of naturally occurring uranium?

The Department believes that the report has adequately addressed these questions and has established several reasonable conclusions. The Department agrees with the overall conclusion that spent fuel is not necessarily the optimum waste form from a disposal viewpoint when compared with other waste forms currently under development. However, this conclusion is reached using elementary analysis and does not consider the relative impact on man from disposal of either type of waste. The conclusion that it will be simpler to dispose of processed high-level waste is based totally on the logistics and mechanics of disposal; it does not include considerations of the waste isolation system's capacity to assure safety.

The Department is strongly supporting reprocessing of commercial spent fuel rather than its disposal as waste. Secretary Edwards outlined the Department's policy on reprocessing and storage of spent fuel in testimony before the Senate Armed Services Committee on March 13, 1981, saying, "So far as reprocessing goes Senator (Thurmond), I feel strongly that this is one of the things we have to do. The President is particularly interested in (industry) moving into the reprocessing business."

While the Department is in general agreement with the major conclusion of the report, certain positions need to be clarified and some comments about the report's focus need to be considered. The report openly acknowledges (page 16) the need for a clear focus on the questions raised.

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Despite this acknowledgement there appears to be considerable drift in the scope of this discussion. Examples of extraneous issues addressed are:

a. Defense high-level waste stored as liquid in tanks and the leaks experienced in previous years (pages 1, 8, 10, and 18);

b. The need for an exploratory shaft as a prerequisite for site selection (pages 30-31).

The points noted above are indeed important to the conduct of the total program, but it is not clear how their inclusion in the report facilitates the analysis of the disposal of spent fuel. The Department would particularly like to request that reference to the defense waste management activities be deleted since there appears to be no connection between that program and the disposal of spent fuel from commercial power reactors.

Chapter 3 appears to be the most important section in presenting the arguments about the disposal of spent fuel versus high-level processed waste. Some very good points are raised, but the data used to support the contentions are not necessarily conclusive. For example, it is concluded that spent fuel repositories must maintain their integrity much longer than high-level waste repositories. The position appears to be based solely on the analysis of the relative toxicity of radionuclides in spent fuel and processed high-level waste. The Department would strongly suggest that this contention be confirmed by other supporting analysis of the isolation capability of the repository. A consequence analysis of this type was done for processed high-level waste and spent fuel repositories for the International Nuclear Fuel Cycle Evaluation and it showed that the consequences of either, under normal and accident conditions, were not significant.

The conclusions drawn at the end of Chapter 3 seemed to be based on the prerequisite that the waste package contain the waste for a period while its relative toxicity is greater than that of uranium. It is not clear why this is a prerequisite for the General Accounting Office since it is not a prerequisite in the Nuclear Regulatory Commission's regulations or the Environmental Protection Agency's standard. Before this requirement is specified by the General Accounting Office, the rationale behind this technical requirement, specifically how failure to comply with it would affect mankind, should be more carefully evaluated.

The Department believes the objectives of the NWTS Program have been overstated in several places. Below the Department has noted these statements and has provided a more accurate statement of its objectives:

a. The Department is not attempting to resolve <u>all</u> unknowns as the basis for implementing a waste repository (page 2). The Department is attempting to resolve the specific uncertainties necessary to assure the long-term isolation of the waste.

b. The Department is not attempting to identify the <u>best</u> possible disposal technology and repository site (page 2). The Department is attempting to develop the technology and identify repository sites that will safely isolate waste from man and his environment.

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c. The Department did not assume that spent fuel could be isolated from the environment as easily as processed high-level waste (page 3). The Department considered the technical problems and times necessary to assure that releases from a repository would not affect mankind. Consequence analyses have shown that either waste form can be effectively contained in a waste repository under normal and accident conditions.

d. The General Accounting Office report states that the Department believes that it has the technology to fabricate a waste package system which will contain the waste for 1,000 years (pages 5, 51, and 53). Some scientists and engineers within the Program have expressed this optimism, but the Department is not yet assured that this position can be demonstrated to the satisfaction of a regulatory body.

e. The Department is not presently planning to bury spent fuel as nuclear waste (page 5). Bury is a term that connotes shallow land disposal suitable only for low-level waste. The Department is developing the capability to dispose of spent fuel should that be required. Even in a reprocessing nuclear economy, every spent fuel element may not be reprocessed. Decisions to dispose of or reprocess spent fuel will be made by the owners of that fuel depending upon the relative value of the fuel compared to the cost of its recovery. For technical or other reasons, it is expected some fuel will go directly to permanent disposal.

f. The Department no longer has an Office of Nuclear Waste Management (page 12). The title of the operation has been changed to Nuclear Waste Management Programs.

g. The Office of Nuclear Waste Isolation (ONWI) has not divided the United States into 11 provinces for the purposes of siting studies (page 19). This sounds like the approach proposed by the United States Geological Survey.

h. The conclusion about the suitability of borosilicate glass applies to the defense waste at Savannah River only (page 47).

Several technical points need to be resolved or clarified in the final document. They are as follows:

a. In a Federal <u>processing</u> plant the spent fuel is not <u>chopped</u> (page 9). The spent fuel is not <u>liquefied</u>; the entire fuel element is <u>dissolved in acid</u>. The Department has restated the points here to promote understanding of how the processing is done in a Federal facility. However, the point is not relevant to the discussion of a commercial reprocessing plant and should be deleted from the report.

b. The report confuses the use of the terms "isolation" and "containment" throughout the document. For GAO's reference the Department defines the terms in the following manner:

-4-

isolation - separation of waste from the accessible environment (biosphere).

containment - confining the radioactive wastes within the prescribed boundaries, e.g., within a waste package.

c. The analysis of the space in a repository for processed high-level waste has not included the disposal of transuranic waste from the commercial fuel cycle which will also have to be placed in geologic repositories (pages 41 through 43). Please refer to the analysis in the Final Generic Environmental Impact Statement entitled "Management of Commercially Generated Radioactive Waste" DOE/EIS-0046 (Volume 1, page 1.9). This question is pivotal to the General Accounting Office's argument. It should be reconsidered prior to drawing a definitive conclusion on which approach needs the least repository area.

d. The radionuclides in spent fuel will not remain toxic for millions of years (page 15) according to the figure on page 39.

The Department of Energy appreciates the opportunity to comment on this draft report and trusts that the General Accounting Office will consider the comments in preparing the final report.

Sincerely,

P. Marshall Ryan
Controller

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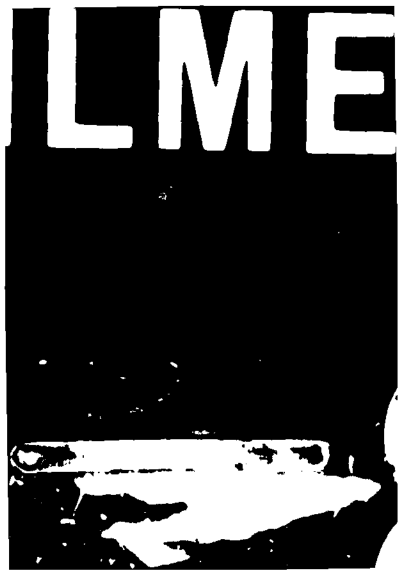
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